Environmental Studies Relative to Potential Sand Mining in the Vicinity of the City of Virginia Beach, Virginia

Part 2: Preliminary Shoreline Adjustments to Dam Neck Beach Nourishment Project Southeast Virginia Coast

Final Report

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U.S. Department of the Interior
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Introduction

The purpose of this report is to 1) describe the shoreline morphology and historical movement of the Virginia's southeast ocean coast from Rudee Inlet to north Sandbridge and 2) document the sediment movement of the recent Dam Neck Beach Nourishment Project (DNBNP) after one year. This study was modified to accommodate the Dam Neck project which came online after the original scope of work for the Minerals Management Service (MMS) was developed. The DNBNP involved placement of over 1,000,000 cubic yards (cy) of sand fill that was dredged from Sandbridge Shoal in Federal waters and placed along about 9,000 ft. of shoreline. Monitoring of the project by VIMS includes before and after aerial imagery, beach profiles and collecting sediment samples. A detailed three year monitoring project is being conducted by the Navy.

Monitoring objectives for the DNBNP included: 1) acquiring low-level aerial photos in order to track the beach planform movement of the beach fill mass; 2) performing beach profiles to document the alongshore changes of beach fill onto adjacent shores; 3) acquiring beach and nearshore sediments to characterize grain size trends as the beach fill disperses; and 4) determining gross bathymetric changes of the nearshore region. Three monitoring periods were determined to be sufficient to accomplish objectives. Detailed monitoring was done for the pre-fill condition (August 1996), post-fill six-months (May 1997) and post-fill one year (Oct 1997).

The DNBNP was completed in November1996. Monitoring of the project for this study extended alongshore from north Sandbridge to Rudee Inlet, a distance of approximately 29,000 ft. The landward extent of the monitoring extended into the dune field roughly 400 to 500 ft.from mean sea level (MSL). Offshore sampling and bathymetry extended to at least the -24 ft. contour, approximately 2,000 ft. from MSL.

In general, Virginia's southeast ocean coast is receding. This ongoing process prompted the Navy to proceed with a large beach nourishment project. With a large sand source just over 3 miles offshore (i.e. Sandbridge Shoal), the DNBNP became a cost effective shore protection option. MMS serves as the government steward of that sand resource and, therefore, is responsible for its wise use. The two-year, five-task monitoring project by the Virginia Institute of Marine Science (VIMS) and Old Dominion University (ODU) will evaluate several facets of offshore sand mining for the purpose of beach nourishment and attempt to determine initial and potential impacts of the DNBNP to benthic resources, modification to the wave climate, tidal current influence and modification the shore zone.

Physical Setting

Geography and Background

The southeast Virginia coast extends from Cape Henry at the mouth of the Chesapeake Bay to False Cape and the North Carolina state line. The False Cape offshore shoal complex and Cape Henry with its associated offshore shoals essentially act as large headland features that bound a long, curvilinear shoreline embayment (Figure 1). This embayed shore includes the coast from Rudee Inlet south to False Cape. The primary study area of Dam Neck lies within this larger shore cell or reach.

The shoreline between Cape Henry and False Cape is a barrier beach and dune system typical of the mid-Atlantic coast. The north half of the reach generally lacks a backbarrier lagoon. The southern half of the reach is backed by North Bay and Back Bay down to False Cape. The only break in this shore reach is Rudee Inlet which has been in existence since at least 1585 (Everts *et al.*, 1983).

Until 1988, the most significant anthropogenic impact in the Cape Henry to False Cape reach was the annual beach nourishment at the Resort Strip that extends from Rudee Inlet northward about 3 miles. The Resort Strip is the commercial, recreational district in the City of Virginia Beach which has been maintained as a recreational, tourist beach through beach nourishment. Sand has been used to recreate the beach yearly since the mid-1950s primarily by truck haul from upland borrow areas and sediment bypassing at Rudee Inlet by cutter head dredge. Approximately 150,000 cy of sand is bypassed annually at Rudee Inlet onto the Resort Strip and another 100,000 to 150,000 cy is trucked in.

In 1988, a second anthropogenic impact to the reach began in earnest. Many residents of the 4.5 mile subreach known as Sandbridge began an extensive bulkheading program to prevent dune erosion. These bulkheads were made primarily of steel, and between 1988 and 1990, about 12,850 ft. of shore was bulkheaded (Basco *et al.*, 1997). By 1995, almost15,545 ft. of shoreline at Sandbridge had bulkheads. Since then, many have failed, have been rebuilt or have been removed.

The most recent anthropogenic impact to Virginia's southeast coast has been the large beach nourishment project at Dam Neck (Fleet Combat Training Center, Atlantic). This project is part of a larger shoreline protection project installed by the Navy at Dam Neck. Before the beach material was placed, a large dune was built using sand from upland sources. This dune, which was constructed with a rock core, is the last line of defense for land based infrastructure the Navy values at about $95 million. Over 1,000,000 cy of borrowed sand from Sandbridge Shoal was pumped onto Dam Neck in November 1996.

Previous Studies of Shore Change

Numerous studies have been performed along the southeast ocean coast of Virginia that pertain to shoreline change. Studies by Everts *et al.* (1983), Dolan (1985), Wright *et al.* (1987), and Basco (1991) document the patterns and rates of shoreline change. Goldsmith (1977), Hardaway and Thomas (1990) and Basco (1997) have performed and analyzed beach surveys along various portions of the reach.

Figure 2 is a composite figure found in Basco (1991) showing shoreline change as determined by Everts *et al.* (1983) and Dolan (1985) as well as shore cells and wave height variation as determined by Wright *et al.* (1987). The general, long-term shore change pattern shows significant shore recession between latitude 36º 40' and 36º 45', just south of Sandbridge,

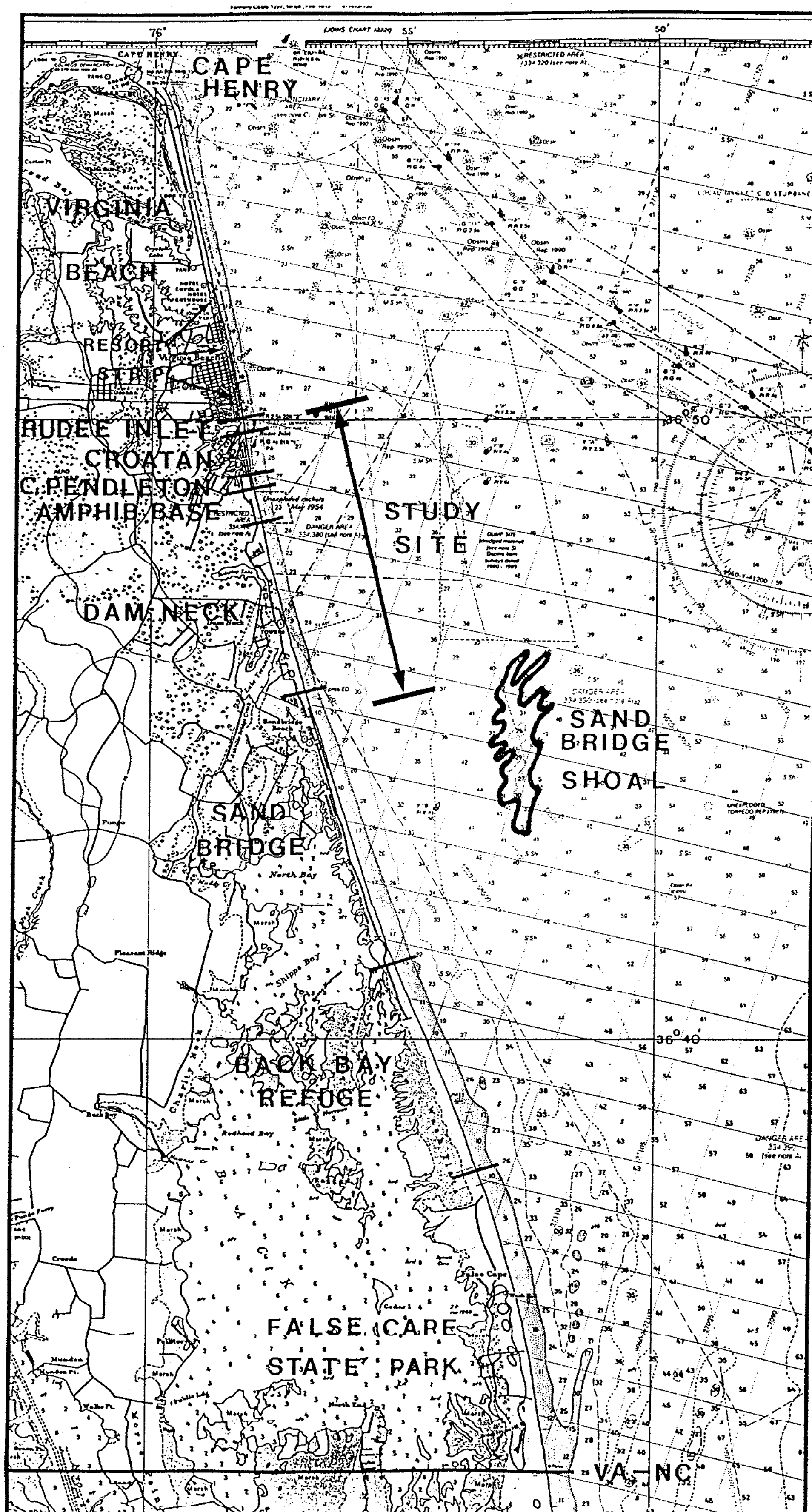


Figure 1. Location of study area.

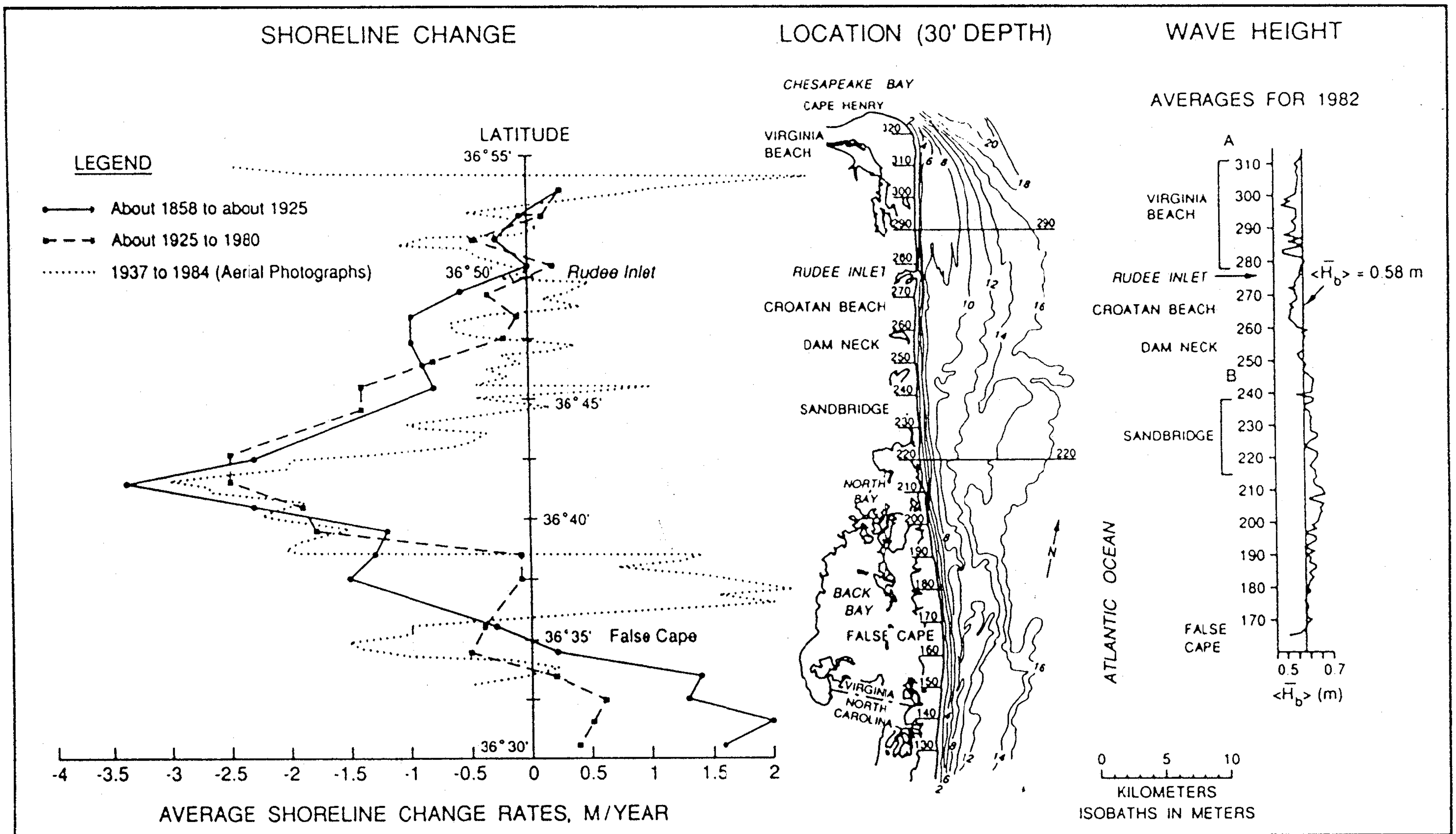


Figure 2. Composite of shoreline change rates (modified from Basco, 1991).

with a maximum erosion rate of 11.5 ft/yr at 36° 41.5' according to Everts *et al.* (1983) and Dolan (1985). This area of high shoreline recession also corresponds to high average breaker wave height (H_b) according to Wright *et al.* (1987). Accretionary trends are evident in several areas of the reach: around False Cape; just south of Rudee Inlet; and at Cape Henry. For the study area between Rudee Inlet and north Sandbridge, the erosion is more variable with some accretionary trends determined by Dolan (1985). These areas have a lower range of average breaker wave heights.

The analysis by Everts *et al.* (1983) is based, in part, on cartographic data using Federal government surveys from 1858 to 1925 and 1925 to 1980 (Figure 2). According to Everts *et al.* (1983), the topographic supplement to the hydrographic surveys were done mostly by plane table. After 1927, aerial photography and photogrammetric methods were used to provide coastal topography (Shalowitz, 1964). The main coastal feature that depicts the shoreline is mean high water (MHW). However, both in the field and from aerial imagery, the determination of this line or datum is somewhat interpretive and can contain a certain degree of error.

The analysis by Dolan (1985) depicted on Figure 2 utilized 47 years of aerial imagery from 1937 to 1984. More recent efforts have attempted to improve shoreline change analysis; several methods and their limitations are presented in Crowell *et al*. (1997), Crowell *et al.* (1991), and Dolan *et al.* (1991). Foster and Savage (1989) determined that the amount of error associated with shore change analysis varies with method. For map data, the error can be +/- 9.1 m, for aerial photos +/- 6.1 m and +/- 3.1 m for surveyed points. One factor is evident, the more closely spaced data points, the better the analysis.

Previous Sediment Studies

The sedimentology of the study area is based on both active processes as well as the underlying geology of the region. Sorting and winnowing of the sediments by the littoral currents and waves occurs continuously in the nearshore region and erosion can expose outcrops of material deposited long ago. Numerous studies have looked at the southeast ocean coast of Virginia in terms of its surficial sediment characteristics, mainly to identify and characterize possible sites for dredging of sand for beach nourishment projects. Williams (1987) studied the area between Cape Henry and Sandbridge. He compiled data from U.S. Army Corps of Engineers core log descriptions to create map of generalized distribution of surficial sediments (Figure 3). Most of the region has muddy fine to medium sand on the bottom. Clean sand is located in a narrow band on the shoreface landward of the 25 ft. contour with a few other isolated areas associated with shoals or relict paleochannels. The areas of mud are located in the thalweg on the western flank of the Chesapeake Bay entrance channel and could be old estuarine outcrops.

Hobbs' (1997) findings essentially agreed with Williams (1987) since his analysis revealed that inner continental shelf (depths less than 100 ft.) is dominated by coarser sediments, most of which contained in excess of 90% to 95% sand. Most sands are medium to coarse sand (>2 phi). Small pockets of fine grained sediments were related to Chesapeake Bay mouth and the others to outcrops of muddy sediments. Berquist and Hobbs (1988) found the inner shelf and shoreface region within 3 miles of the Sandbridge shoreline, depths generally less than 50 ft., have surface sediments of uniform gray to olive gray, fine to very fine sand with a consistent mean grain size of

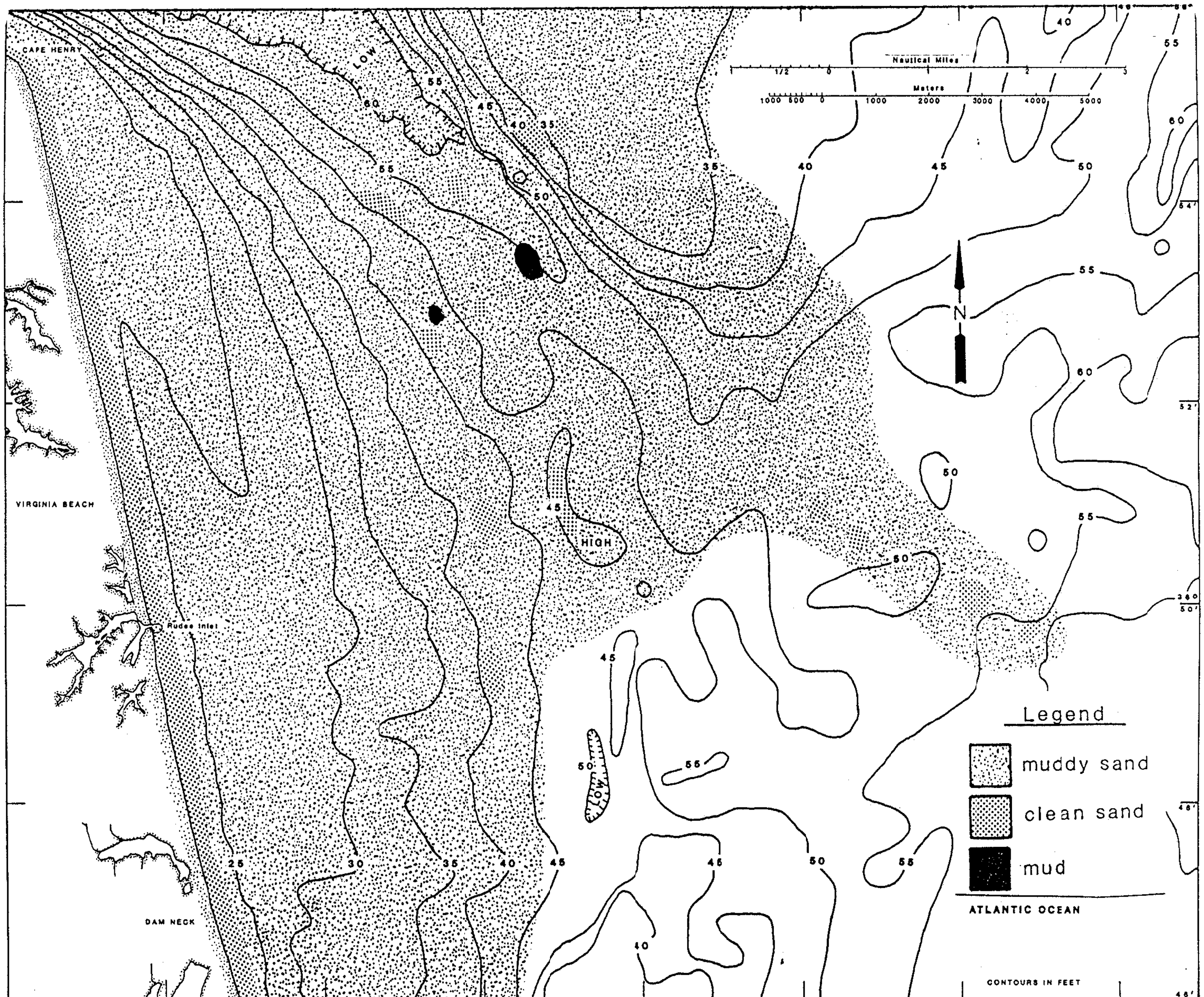


Figure 3. Surficial sediment distribution offshore Virginia Beach (from Williams, 1987).

0.125 mm (3.0 phi). The percentage of mud is high ranging from 16% to greater than 20%. Hobbs (1997) concluded that the sediments of southeastern Virginia ocean coast is more varied than previously thought. Even though most are sands, the density of the sampling grid allows identification of a greater spatial variability in grain-size characteristics.

Kimball and Dame (1989) used vibracores to confirm the characterization of sediments within Sandbridge Shoal as “medium grained sands” with mean grain size of 0.3 mm (1.5 phi); many samples had over 10% by weight pebbles. Their study of the bottom near Rudee Inlet indicated the region had a surface mean 3.05 phi (0.12 mm) and a standard deviation 0.5 phi, (0.71 mm). Off of Sandbridge the mean was 1.5 phi (0.35 mm) and the standard deviation was 0 .5 phi (0.71 mm).

Wright *et al.* (1987) summarized beach sediment data from various sources. There is considerable variability both cross-shore and alongshore, but in general, the average foreshore (beach between the berm and the beach TOE) mean along the Resort Strip in Virginia Beach was 2.0 phi (0.25 mm) and had a standard deviation or sorting value of 0.8 phi (0.57 mm). At the -10 ft.contour the $D_{50,}$ or median, varies between 2.3 phi and 2.5 phi (0.18 mm and 0.20 mm). Between Rudee Inlet and Fort Story, the D_{50} increased threefold (0.25 mm to 0.75 mm) from south to north. Between Rudee Inlet and Back Bay, the D_{50} of the oreshore is larger than other subaerial samples, and the D_{50} at -10 ft.contour is 2.1 phi (0.23 mm). On a winter beach, the minimum D_{50} seaward of the foreshore is 1.9 phi (0.26 mm) and varies to a maximum of 1.6 phi (0.32 mm). Sandbridge has a foreshore mean 1.75 phi (0.3 mm). Wright *et al.* (1987) suggest that a beach nourishment program along the Dam Neck/Sandbridge reach would best be served with sand larger than 2.0 phi (0.25 mm). The average grain size of the DNBNP is 0.4mm (1.2 phi).

Waterway Surveys and Engineering (1986) conducted an analysis of the beach at Sandbridge. Their study found that the D_{50} of the dune face or the base of the bulkhead ranges from 2 to 1.2 phi (0.25 to 4.0 mm) which is medium sand. This range also occurred in the midberm region. The D_{50} of the foreshore portion of the beach ranged from 2.3 to 1.0 phi (0.2 to 0.5 mm) and is classified as fine and medium sand. The low tide terrace had a D_{50} range of 2.3 to 2 phi (0.2 to 0.25 mm) which is fine sand. In general, the foreshore sands are coarsest with the backshore and dune slightly less coarse than foreshore. The outer part of low tide terrace has the finest sand, even finer than the samples from the 10 ft. depths. Sorting is best at outer edge of low tide terrace and on the dunes and in the backshore.

Hydrodynamic Setting

Wave Climate

For this study, the main hydrodynamic forces operating along the project area are the waves and wave-induced currents and tidal currents. The wave climate operating along the southeast Virginia coast is controlled, in part, by the nearshore bathymetric configuration and tidal currents (Ludwick, 1978; Wright *et al.*, 1987). Influence by tidal inlets is negligible, except locally at Rudee Inlet. Wave measurements at several locations including NOAA buoy 44014

(Figure 4) from Maa (1995) and WIS phase III stations 77 and 78 (Figure 5) from Jensen (1983) indicate a dominant southeasterly component to the wave field. However, the predominant storm direction is from the northeast and tends to counter the southeasterly-driven, longshore movement of beach material.

The distribution of the longshore component of wave energy along the southeast Virginia coast is controlled by the nearshore bathymetry. Wright *et al.* (1987) performed a wave climate analysis using a linear wave propagation model, RCPWAVE, developed by the U.S. Army Corps of Engineers (Ebersole *et al.*, 1986) that computes changes in wave characteristics that result naturally from refraction, shoaling, and diffraction over complex shoreface topography. The results of the analysis in Wright *et al.* (1987) indicate a concentration of wave energy in the area just south of Sandbridge. This corresponds to a nearshore increase in water depth where higher potential wave energies may reach the coast (Figure 2). This region also has the highest rate of shoreline recession on the southeast Virginia ocean coast and is considered an area of divergence, or a "nodal" zone, where shore zone sediments are transported northward and southward toward Cape Henry and False Cape (Everts *et al.*, 1983).

Further complications in nearshore bathymetry exist due to the occurence of Sandbridge Shoal (Figure 1). Maa (1995) indicates that the existence of Sandbridge Shoal may tend of concentrate wave energy into the area of high shoreline recession. Boon (1997) found a similar tendency. The inference here is that removal of Sandbridge Shoal due to mining for beach nourishment may decrease the wave concentration in the area of highest shoreline recession.

The onshore-offshore component of sediment transport at Sandbridge was described by Wright *et al.* (1991). Wave gauge deployment during November 1988 on the shoreface of Sandbridge embraced some contrasting moderate wave energy events and provided insight into the processes that operate during non-storm autumn and winter periods. The results for Sandbridge indicate that incident waves are the principal agent of sediment flux and suggest that wave-driven transport in the seaward direction may be nearly as important as in the shoreward direction (Wright *et al.*, 1991).

On a regional scale, the nearshore zone along the southeast coast of Virginia influences the wave climate because the False Cape and Cape Henry shoal complexes tend to act as headlands. The southeasterly wave field is impacted first by the False Cape headland which refracts and diffracts the wave field. Northeasterly waves are refracted and diffracted by the Cape Henry shoals. Sediments of the shore and shoreface are driven both north and south from the nodal divergence zone by the impinging wave climate to help "feed" the adjacent headland shoal areas. The headland shoals display a much gentler offshore bathymetric gradient than the nodal divergence area. A steeper shoreface bathymetric gradient near the nodal point allows significant "planing" by wave processes and sea-level rise that cut into the underlying coastal strata which serves as a sediment source (Swift *et al.*, 1985).

Sediment Transport

Everts *et al.* (1983) described the divergence or nodal zone just south of Sandbridge where transport processes cause alongshore sediment movement north and south. This was

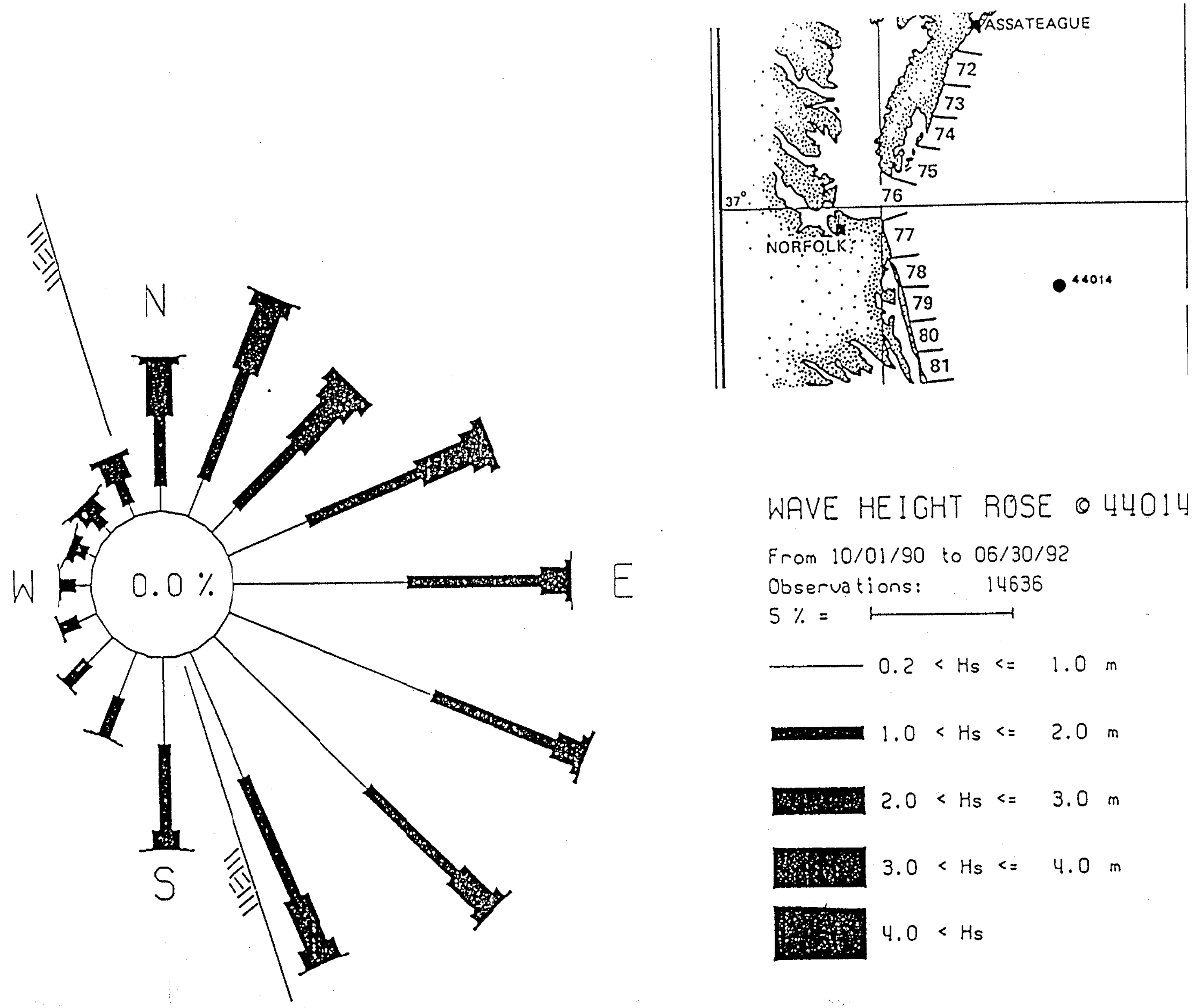


Figure 4. Wave rose diagram from NOAA Buoy 44014 (from Maa, 1995) and locations of Buoy and Wis Stations.

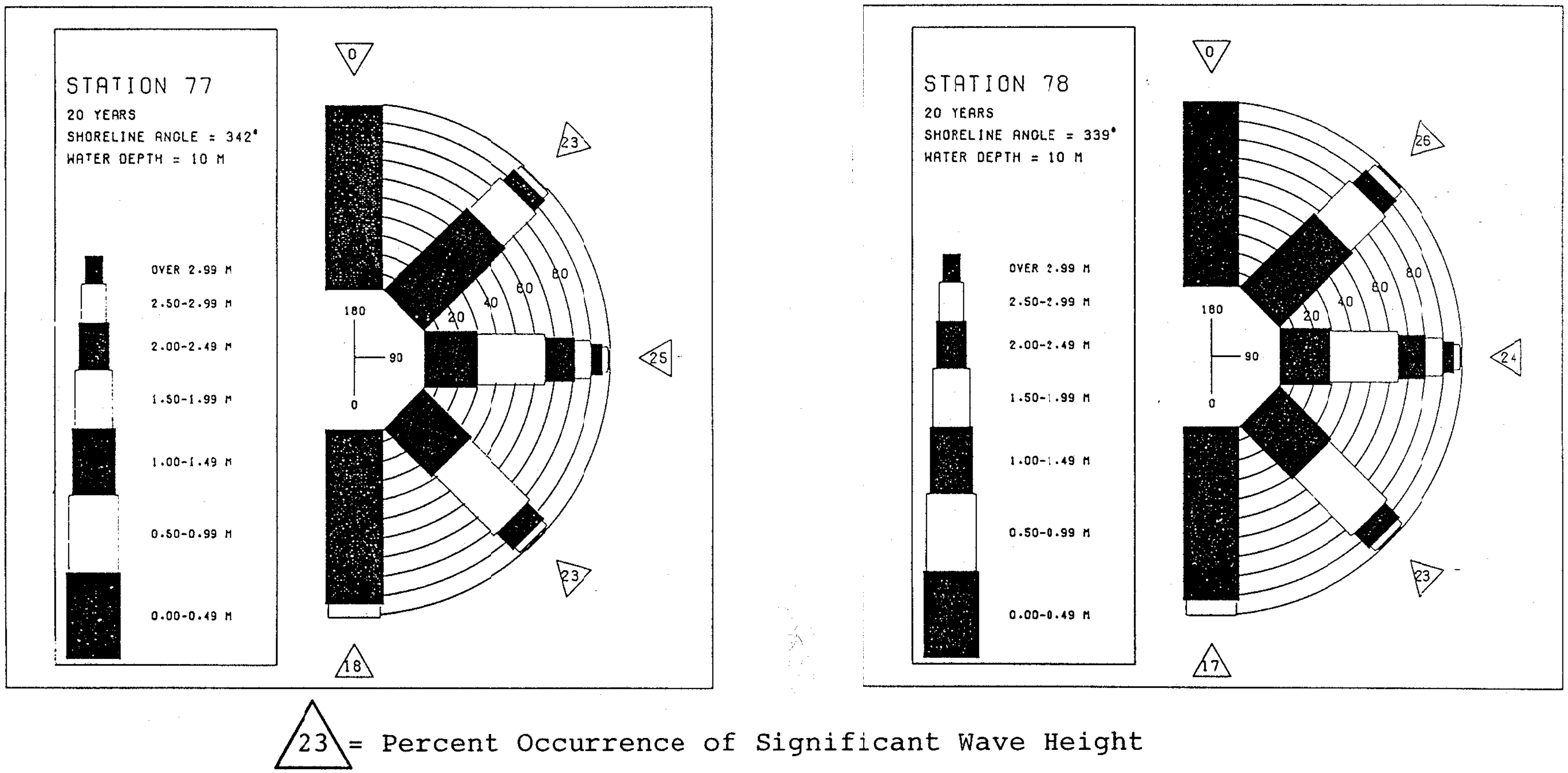


Figure 5. Wave rose diagram from WIS Phase III stations 77 and 78.

substantiated by Waterways Surveys and Engineering (1986) and Wright *et al.* (1987). Waterways Surveys and Engineering (1986) determined sediment transport rates from sedimentation and dredging of Rudee Inlet. They estimated a gross transport rate (Q) to the north of 488,000 cy per year and a Q to the south of 288,000 cy per year. This results in a net northerly alongshore rate of 200,000 cy of sand per year. The implication at Dam Neck would be a similar net rate of alongshore sediment transport to the north. Onshore-offshore transport is not included in this estimate but may be a significant factor related to the DNBNP.

Methods

Shore Profiles

A long-term beach and nearshore profile survey data set was obtained from the City of Virginia Beach's survey department. This data set was created between 1980 and 1996 and includes dune and beach surveys to MLW. Early surveys were taken each quarter (i.e. spring, summer, fall and winter). Two times per year, select profiles (numbered 43, 45, 48) are run offshore to approximately 25 ft. below mean sea level (MSL). The survey methods include transit and stadia for the beach and dune portions of the profile and fathometer and sled for the offshore section. For this project, eight of the City's profiles, numbered 43 to 50, from Rudee Inlet to the north end of Sandbridge were analyzed (Figure 6 and Table 1). Profiles 43 and 44 define the boundaries of Croatan Beach. Profile 45 is on the Naval Amphibious Base property. Profiles 46, 47 and 48 are on Dam Neck property, and profiles 49 and 50 occupy the north end of Sandbridge.

The location of VIMS's survey at profile 43 was slightly south and about 25 ft. in front of the City's profile since the City's profile crosses the beach near the groin, and sediment samples could not be taken directly offshore. The City stopped survey profile 45 in 1984 and profile 46 in 1990 (Table 1). Access to profile 45 was difficult since it is a military training area; the City's benchmark was not recovered. VIMS personnel set a wood stake at the approximate location of profile 45 and used the Global Positioning System (GPS) to locate the stake and get an elevation. The City benchmark at Profile 46 still exists, but surveying is difficult since it is a military rifle range. The benchmarks at profiles 47 and 49 were reset in 1996. Profile 49 was reset in about the same location, but profile 47 was moved about eight ft. north and 25 ft. east.

The City's raw data from field books were databased with the Interactive Survey Reduction Program (ISRP) (U.S. Army Corps of Engineers, 1994). The data was plotted and checked for errors and bad points. Profile analysis followed procedures outlined by Larson and Kraus (1994). This includes an analysis of individual profile parameters including change in the position of MHW, the average shoreline change through time, seasonal plots, and the maximum and minimum, the mean profile and standard deviation.

The profiles were surveyed by the City in August 1996 before the DNBNP. The same profile lines were surveyed by the VIMS six months (May 1997) after installation and one year later (October/November 1997). The subaerial beach, out to 2 ft. below MLW, was surveyed in detail with transit and stadia. Due to lack of high resolution offshore survey gear, only depth change at the position of sediment sampling was measured (see section C, below). Sediment

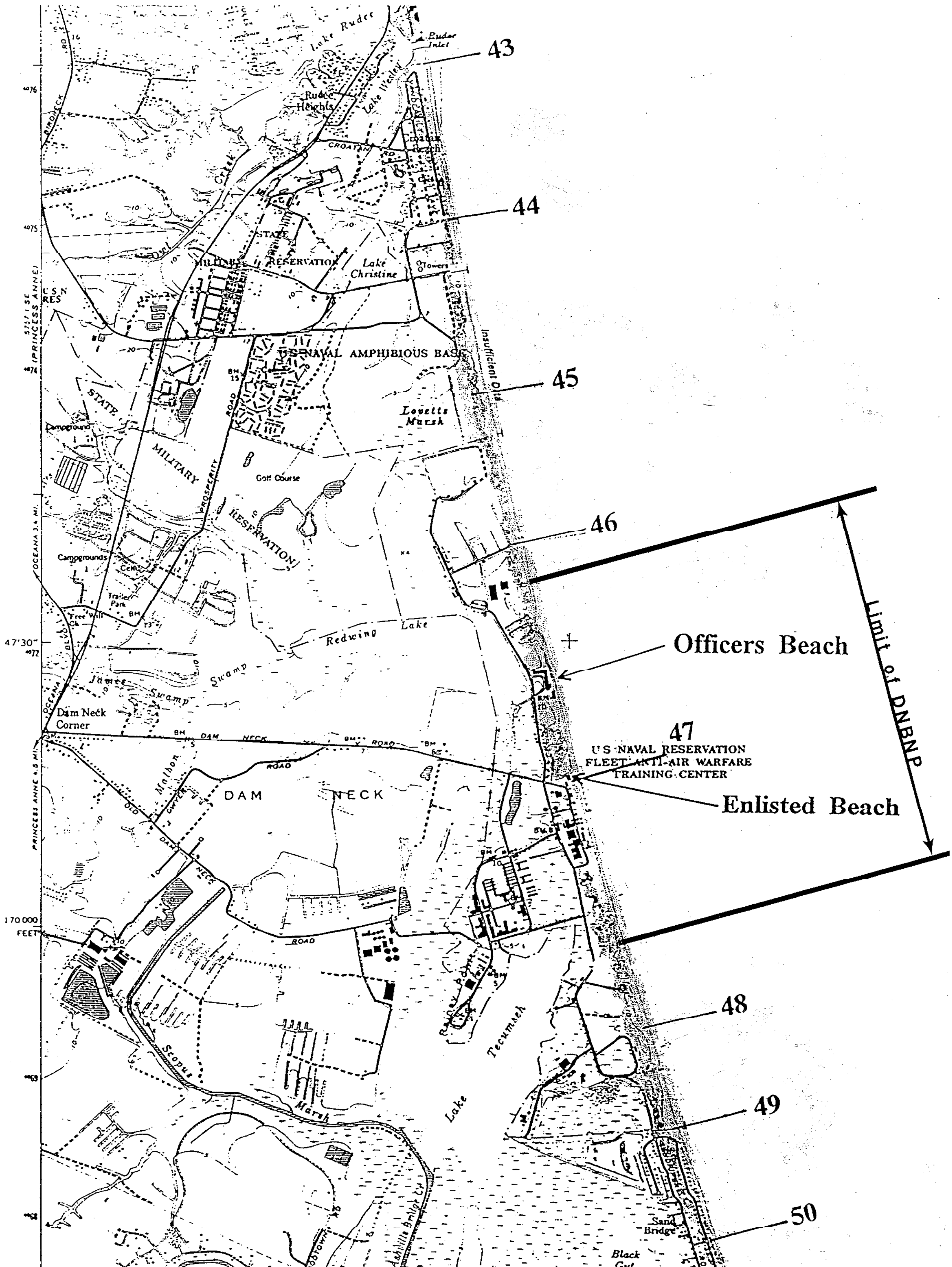


Figure 6. City of Virginia Beach profile locations 43-50.

samples also were acquired at each date for the beach and offshore regions, to a depth of 24 ft. below MSL.

Aerial Imagery

VIMS operates a U-6A DeHavilland Beaver to further its research and educational mandates. The very low minimum controlled flight speed is an asset both to aerial observation and photography and to operations in and out of short, unimproved landing areas. VIMS can obtain vertical photography in 70-mm format on a variety of film types. Two Hasselblad 500ELM cameras can be used together allowing the acquisition of identical images on two different film types. The cameras are equipped with motor driven film advances, simultaneously controlled, electronic shutter releases, and an intervalometer.

The study site was flown by VIMS's plane and personnel before the fill project (August 1996), just after the project (November 1996), in April 1997, and September 1997 to obtain low-level vertical imagery. Eight inch square, non-rectified photos with 60% overlap at a scale of 1"=200' were obtained. A mosaic was created with the photos and used to plot the position of MHW through time.

Sediments

Sediment sampling locations followed the general plan outlined in Figure 7. Sediment grab samples were taken along profiles 43 to 50 prior to the DNBNP (August 1996), after six-months (May 1997) and after one year (October/November 1997). Dune, beach and nearshore samples to -2 ft. MLW were taken by hand from shore. Offshore sediments at -6, -12, -18 and -24 were acquired with a grab sampler from a boat. Three grab samples were taken for each offshore location to create a composite sample.

Offshore sampling for the three sampling periods was based on returning to the same location (i.e. latitude/longitude) each time by using a differential GPS. Depths for the second and third sampling period may have changed, but the sample names remained the same. Dune, beach and nearshore samples were taken at the designated morphologic feature (i.e. dune, berm, mid-beach, etc.). Sediments were analyzed for percent gravel, sand, silt and clay. The VIMS Rapid Sand Analyzer (RSA) was used to determine the grain size distribution of the sand fraction. Sediment sample information is in Appendix A including the latitude and longitude position of the offshore samples and the distance from the benchmark of the beach samples.

The grain size distribution of beach sand generally varies across the shore and to a lesser degree, alongshore as a function of the mode of deposition. The coarsest sand particles usually are found where the backwash meets the incoming swash in a zone of maximum turbulence at the base of the subaerial beach; here the sand is abruptly deposited creating a step or TOE. Just offshore, the sand becomes finer. Another area of coarse particle accumulation is the berm crest, which is sometimes coincident with the last high tide line (LHT), where runup deposits all grain sizes as the swash momentarily stops before the backwash starts. The dune or backshore generally contains the finest particles because deposition here is limited by the wind's ability to entrain and move sand (Bascom, 1959; Stauble *et al.*, 1993).

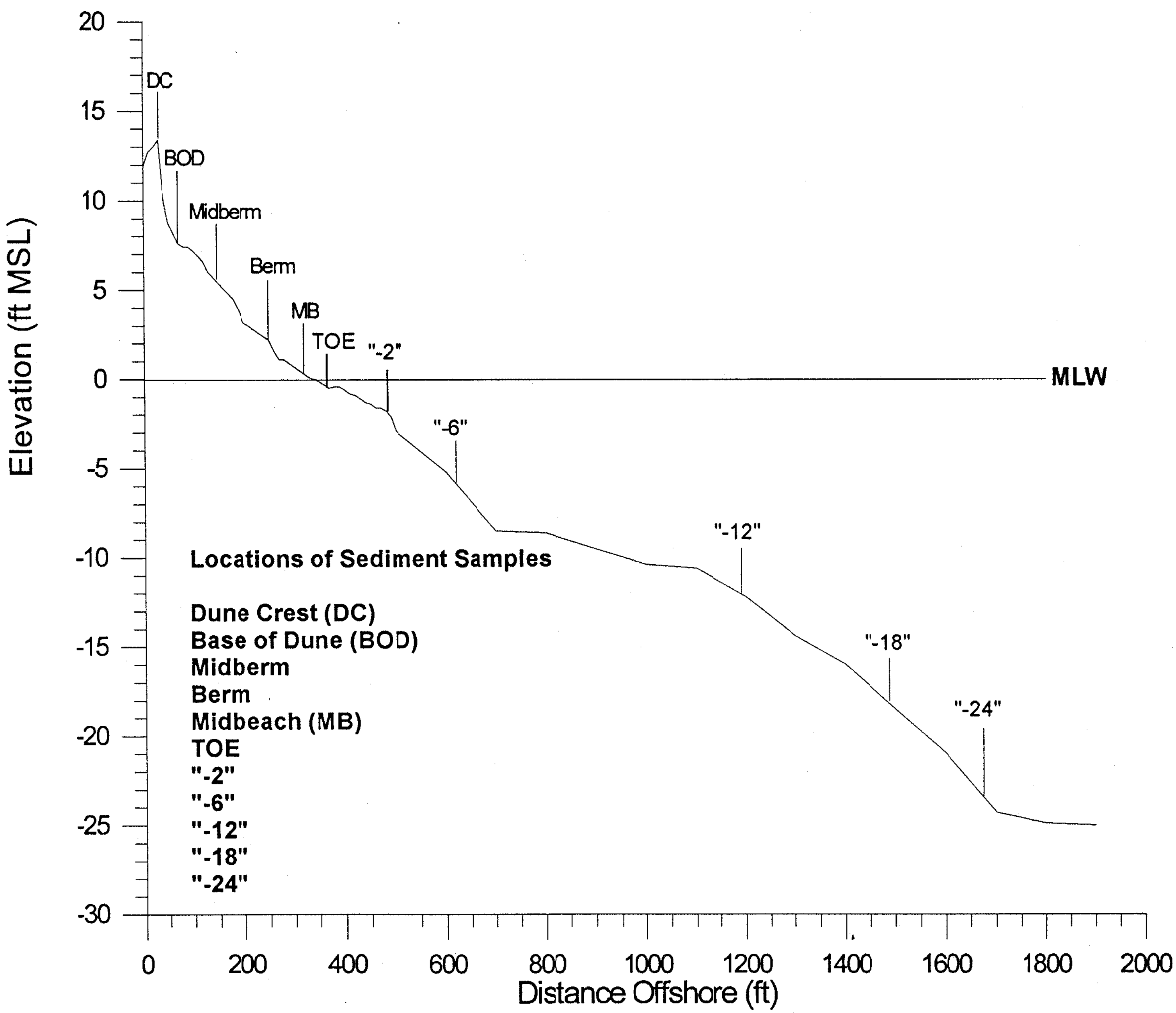


Figure 7. Typical profile and morphologic features with sediment sample locations.

Sediment statistics were developed for median grain size and sorting. Both statistics are common parameters in discussing sediment characteristics and are used frequently in beach assessments (Stauble *et al.* 1993; Larson and Kraus, 1994). The median is defined by one half the particles are coarser and one half are finer, but it is not particularly useful for bimodal sediments. The mean is a better parameter but the median is most commonly used (Folk, 1980). Sorting is a measure of sediment uniformity and can be obtained by several methods of determining standard deviation. The spread of the grain size distribution about the mean defines the concept of sorting. Well-sorted sands have only a few size classes present in the sample. Poorly-sorted sands are represented by most size classes (Friedman and Sanders, 1978). For this study, the Inclusive Graphic Standard Deviation (Folk, 1980) is used. The method of moments was used on the sediment data (Appendix A), but even though it is generally a more accurate method of describing a sample, it is not discussed since previous studies of the sediment characteristics of Virginia's southeast coast utilize the graphic method of statistic determination.

Table 1

Station	Designation	Mark	NAD 1983 (ft) 198	NAD 1983 (ft)	NGVD 1929	Date	Total	Inclusive	Long
VIMS	Virginia Beach	Type	Northing	Easting	Elevation	Established	Surveys	Dates	Short
43	M-07 (Reset)	Disk	3,471,104.9210	12,223,512.1990	11.28	August 1982	33	1980-1996	L
44	PRO 5-2	Disk	3,467,422.8220	12,224,120.0630	18.79	July 1980	33	1980-1996	S
45	M-08	Disk	3,464,472.3276	12,224,827.4200	15.22 (1929)	July 1980			
	DN3 (VIMS)	Stake	3,463,509.2776	12,225,077.4048	21.65 (1983)	August 1996	17	1980-1984	L
46	PRO 6-2	Disk	3,459,920.4941	12,225,924.9005	22.691	June 1980	22	1980-1990	S
47	N-010	Disk	3,454,568.3790	12,227,383.0190	22.98	July 1980			
	N-010A	Disk	3,454,576.4990	12,227,407.8060	22.81	1996	32	1980-1996	S
48	PRO 7-2 (Reset)	Disk	3,448,874.9164	12,229,068.5090	13.071	June 1980	32	1980-1996	L
49	PRO 8-2	Disk			15.55	June 1980			
	PRO 8-2A	Disk	3,446,301.3690	12,229,839.4310	14.22	1996	34	1980-1996	S
50	N-012	Disk	3,443,888.5360	12,230,750.8950	8.57	June 1980	29	1980-1996	S

Information on the City of Virginia Beach's profile data.

Results

Long-Term Historical Trends

The long-term rate of shore change at the location of the eight study profiles was determined by Everts *et al*. (1983) (Figure 8) and is summarized in Table 2. The MHW position was determined for each date at each profile location. From 1859 to 1925, there is a similar rate of shoreline erosion for all profiles that ranges from -4.5 ft. per year (ft/yr) at profile 46 to -2.9 ft/yr at profile 49. The trends from 1925 to 1980 show similar magnitude of recession between profiles 47 to 50. However, a significant accretionary trend becomes evident in profiles 43 and 44, a reduced erosion rate at profile 45 and slight accretion at profile 46. This may be attributable to the stabilization of Rudee Inlet by jetties and the subsequent bypass system. The jetties would act as littoral barriers that stack sand to the south. The jetties and inlet dredging significantly modify the net long-term trend from 1859 to 1980 for profiles 43 and 44.

Table 2

	Historic	Shore (ft/yr)	Change*	Virginia *Net*	Beach *Shore* (ft/yr)	Profiles *Change*	Average Change (ft/yr)
Date	1859-1925	1925-1980	1859-1980	1980-1996	1980-1984	1980-1990	
Span (yrs)	66	55	121	16	4	10	
Profile #							
43	-3.0	5.1	0.66	2.9			19.4
44	-3.0	0.5	-1.7	1.2			12.9
45	-3.6	-0.91	-2.4		-3.8		1.8
46	-4.5	1.4	-2.1			-2	1.4
47	-3.0	-2.0	-2.5	-5.4			-1.9
48	-3.3	-2.55	-3.1	-0.6			-0.4
49	-2.9	-4.4	-3.4	-0.6			4.7
50	-3.2	-3.82	-3.5	-3.4			-4.9

* Data from Everts *et al*. (1983)

Shoreline change rates from historical data and the City of Virginia Beach's data set.

City Monitoring, 1980-1997

Analysis of the City's beach survey data shows the variability of shoreline and shoreface change along this subreach over the past 16 years. One portrayal of shore change is the movement of a tidal contour through time. Following historical methods, the position of MHW for each study profile was plotted through time (Figures 9A-9H). Except for the very high

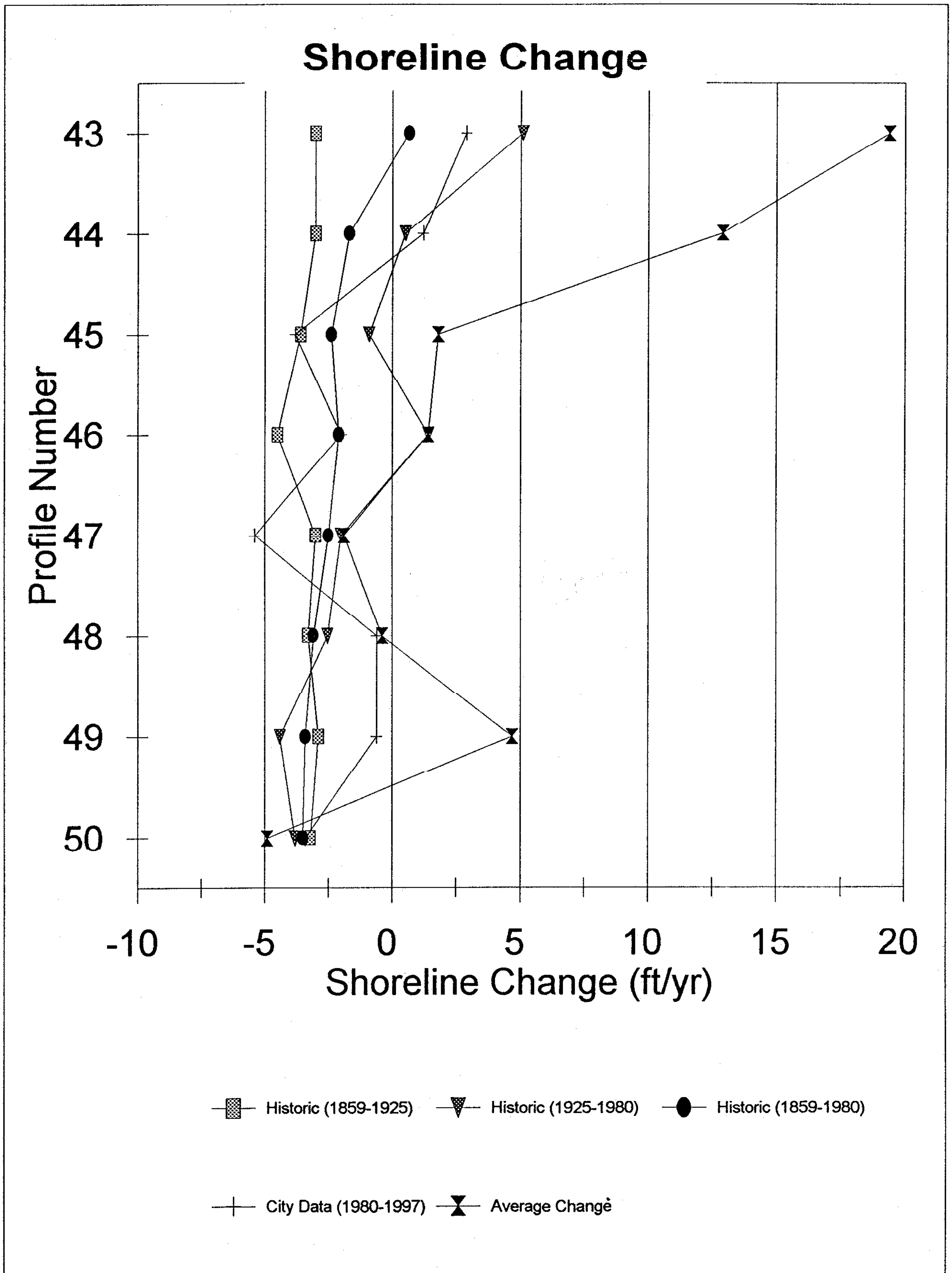


Figure 8. Historical shore change for the eight study profiles (long-term data from Everts *et al.*, 1983 and City data).

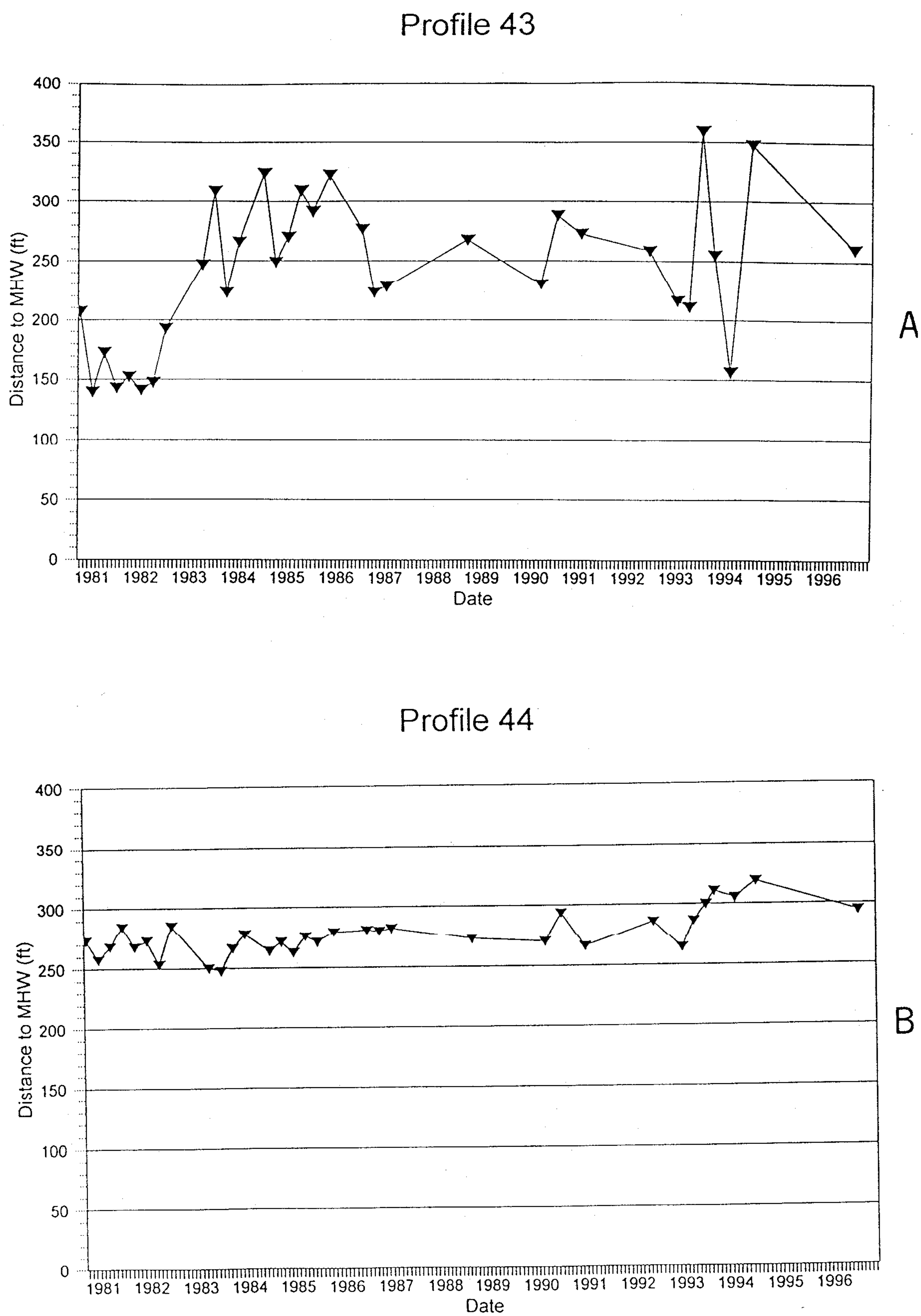
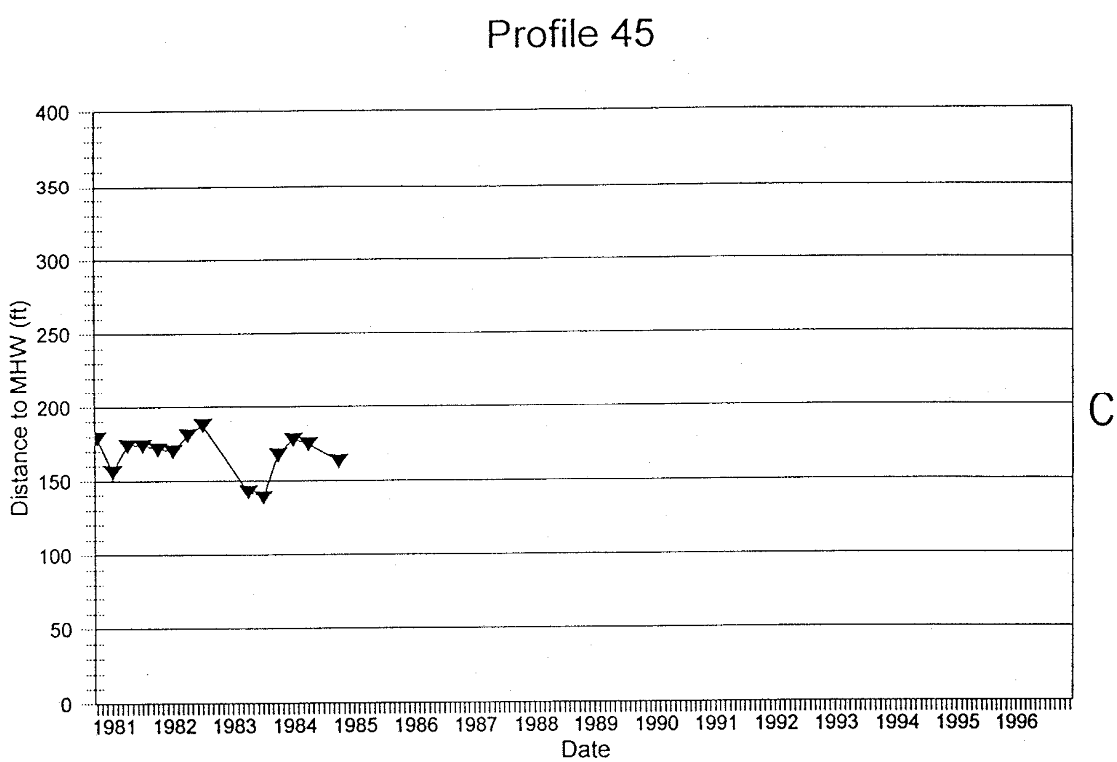


Figure 9. Change in position of MHW for A) profile 43 and B) profile 44.



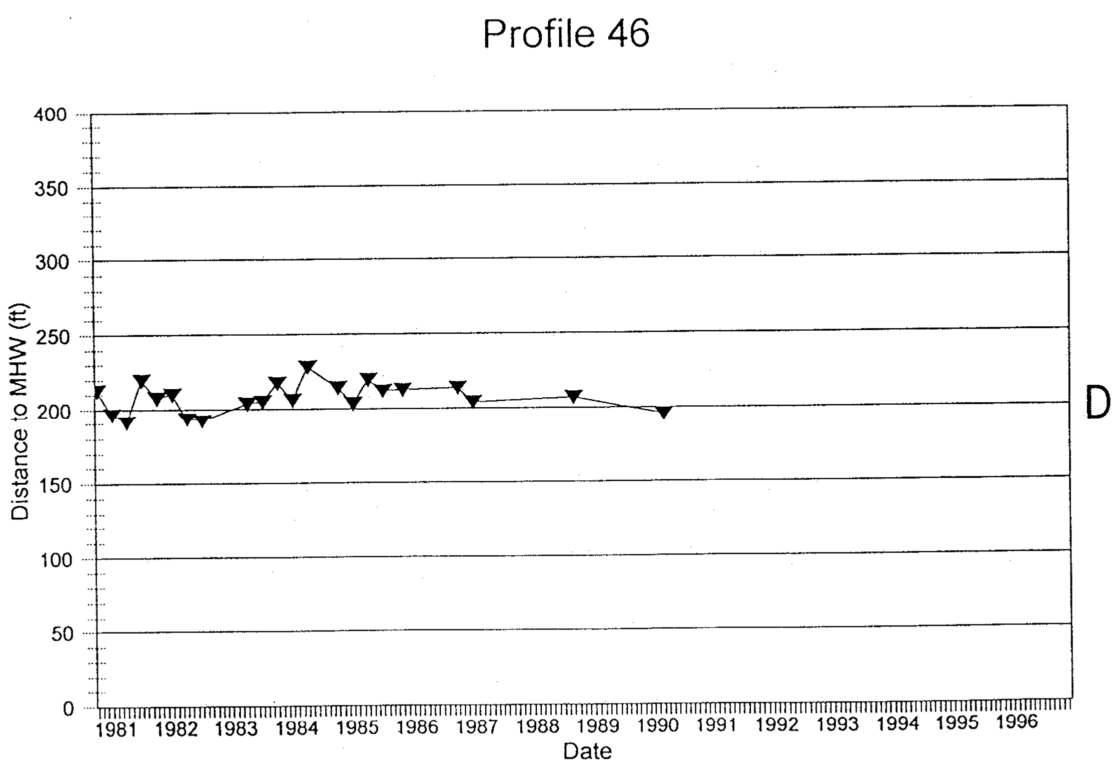
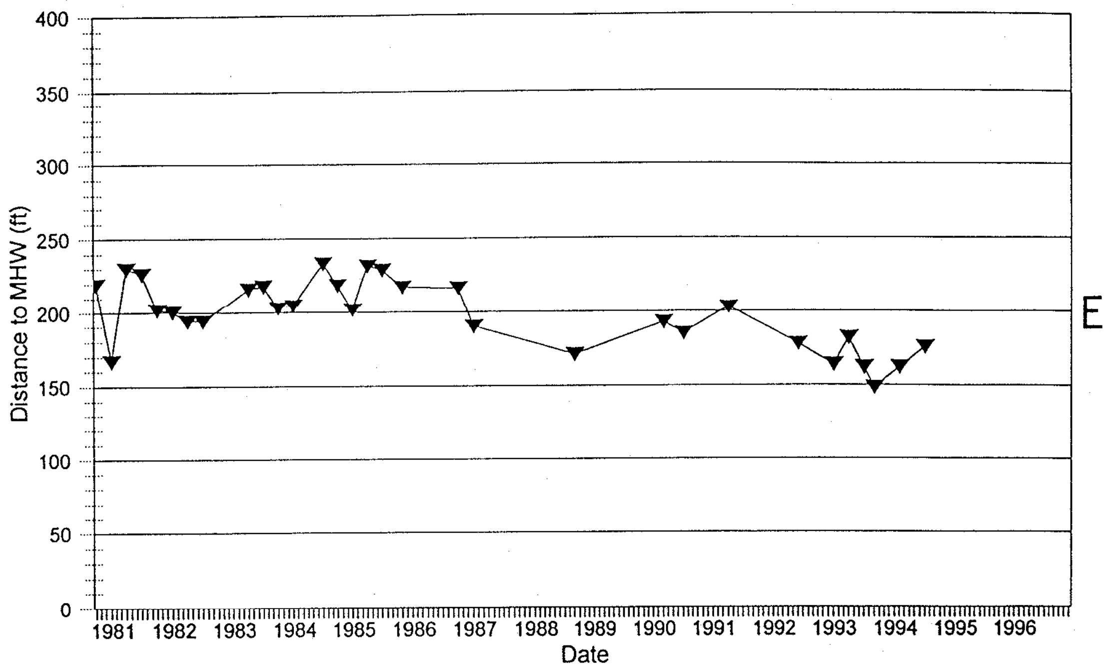


Figure 9. Change in position of MHW for C) profile 45 and D) profile 46.

Profile 47



Profile 48

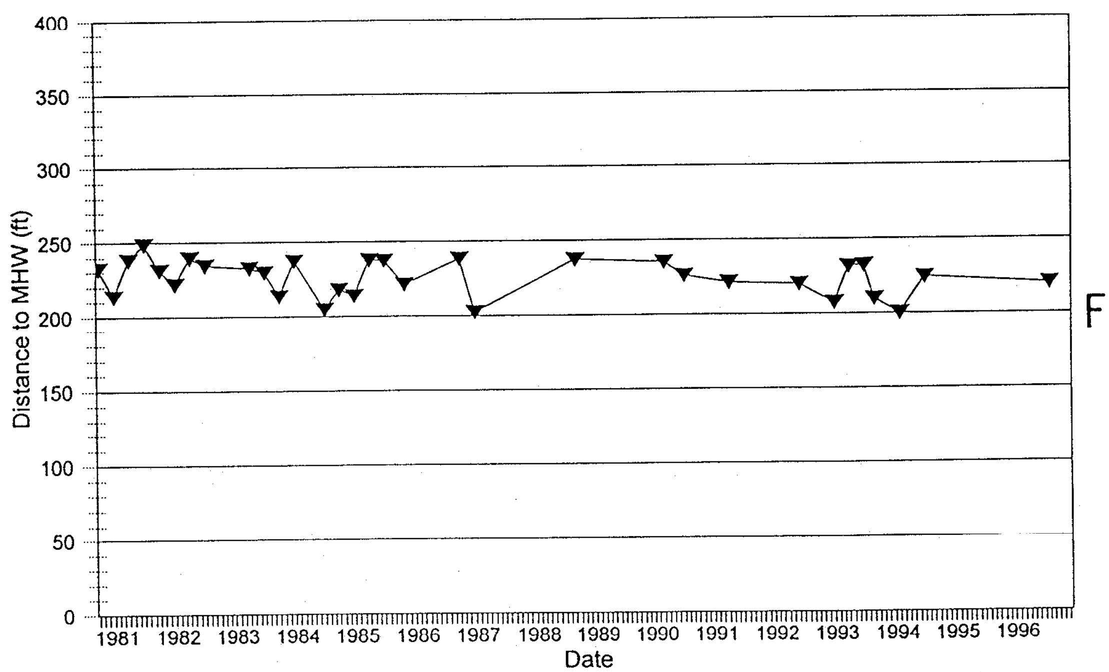
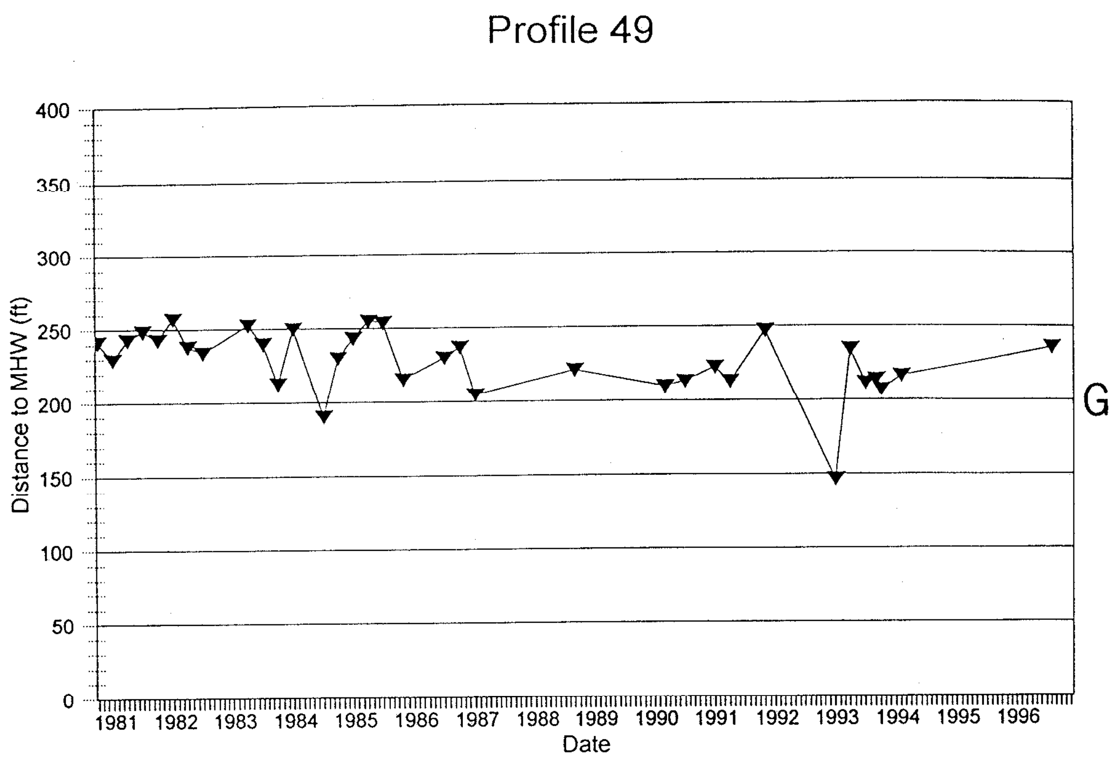


Figure 9. Change in position of MHW for E) profile 47 and F) profile 48.



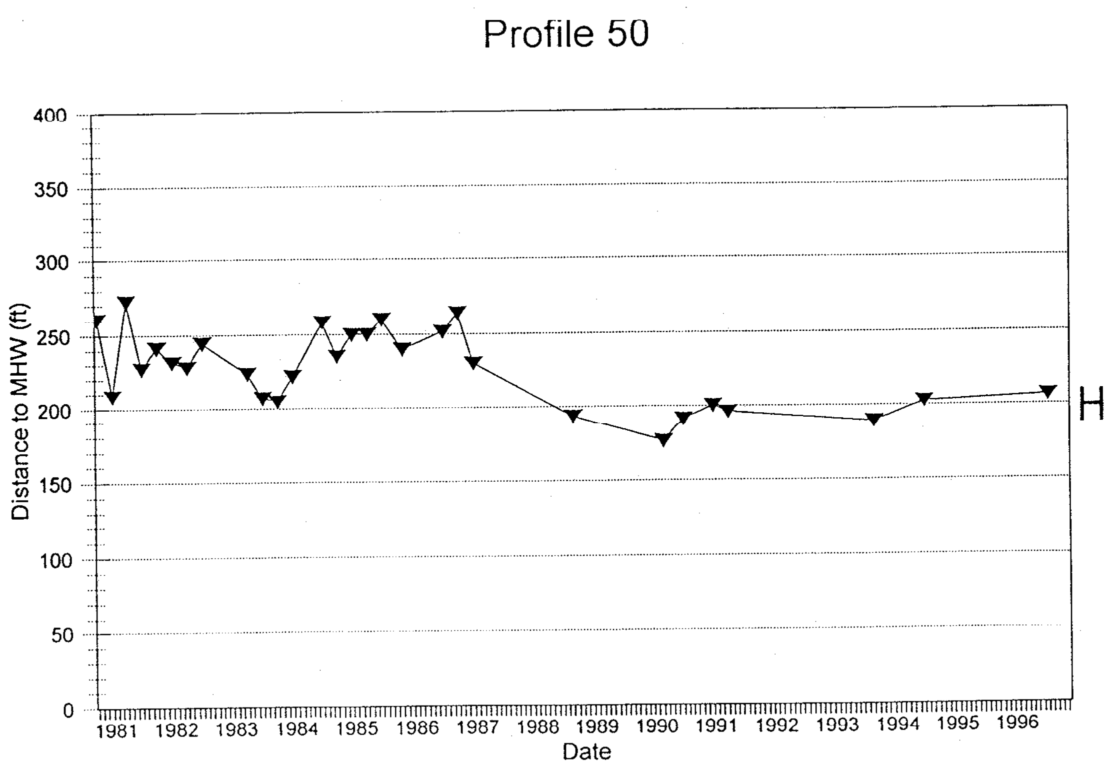


Figure 9. Change in position of MHW for G) profile 49 and H) profile 50.

variability in profile 43 (Figures 9A), the other profiles indicate large seasonal fluctuations where data was taken quarterly and possibly a subtle trend toward erosion, accretion or relative stability depending on the individual profile. The rate at which these trends occur along this subreach has broader regional implications as modifications to the shoreline continue to have an impact (i.e. Sandbridge bulkheads, DNBNP, and a proposed beach nourishment at Sandbridge).

A simple method to determine rate of change is the **End Point Rate** method (EPR), described by Fenster *et al.* (1993), which is similar to picking a tidal datum off aerial imagery in its relative randomness. For example, for this study, the difference between the positions of MHW at two dates were multiplied by the number of years between the dates to get a rate of change in ft/yr for each profile. These rates are shown in Figure 8 and compared against rates from Everts *et al.* (1983). Since this method is similar, these data could be the position of MHW from two aerial photos flown at those times. However, all in all, the trends using the **EPR** are similar to the historical plots.

In order to ascertain an overall trend for each profile, the <u>average</u> shoreline change at MSL in ft/yr was determined (Figures 10A-10H). This average of the rates through time for each profile also is plotted against the historical trends and the values obtained by the EPR method (Figure 8). The plot describes the accretionary trend that is being enhanced by Rudee Inlet. Although more detailed analysis is necessary, the present study shows an increased rate of accretion south of Rudee Inlet according to City data. This trend appears significant down to profile 46 with profile 43, which is adjacent to Rudee Inlet, having the highest average rate of shoreline change at +19.4 ft/yr. Shoreline recession continues at profiles 47 and 48 but at less than historical rates. Finally, the north end of Sandbridge has an increased accretion rate at profile 49 and a corresponding loss at profile 50. This plot includes data prior to and after bulkheading began in 1988 which, no doubt, modifies the natural trend.

Seasonal fluctuations across the study profiles, shown in Figures 11A-11H, are plotted along with the average profile for all surveys. Table 3 lists the survey dates that were assigned to each grouping used to determine the seasonal mean profile. The mean seasonal profiles are represented for winter, spring, summer and fall by January, April, July and October, respectively. Generally, subaerial beach accretion occurs in the summer or fall; beach erosion occurs in the winter or spring. The plots show that the July or summer profile has the highest berm. Most of the profiles are lowest in January except profiles 43, 44 and 45 which have their lowest profiles in April. Both the January and April mean profiles can be indicative of a winter profile. The maximum vertical change occurs across the beach berm feature between +4 and +6 ft. MSL and the backshore region. This is the active subaerial beach and swash zone that is subject to frequent wave runup and overtopping. Profile 50 shows the development of a nearshore bar on the January mean profile indicating that sand is stored in a bar system during the winter.

Since the long profiles (43, 45 and 48) generally are surveyed only in the spring and fall, mean profiles plotted for winter and summer do not extend beyond about MLW. The offshore trend shows that there is a “crossing point” on the long profiles where the inshore portion of the profile to MLW show accretion in the fall and erosion in the spring. Seaward of the crossing, the trend is less clear, but, generally, the opposite is occurring with profile accretion in the spring and erosion in the fall. After a summer of milder waves, sand has moved closer to the shoreline since

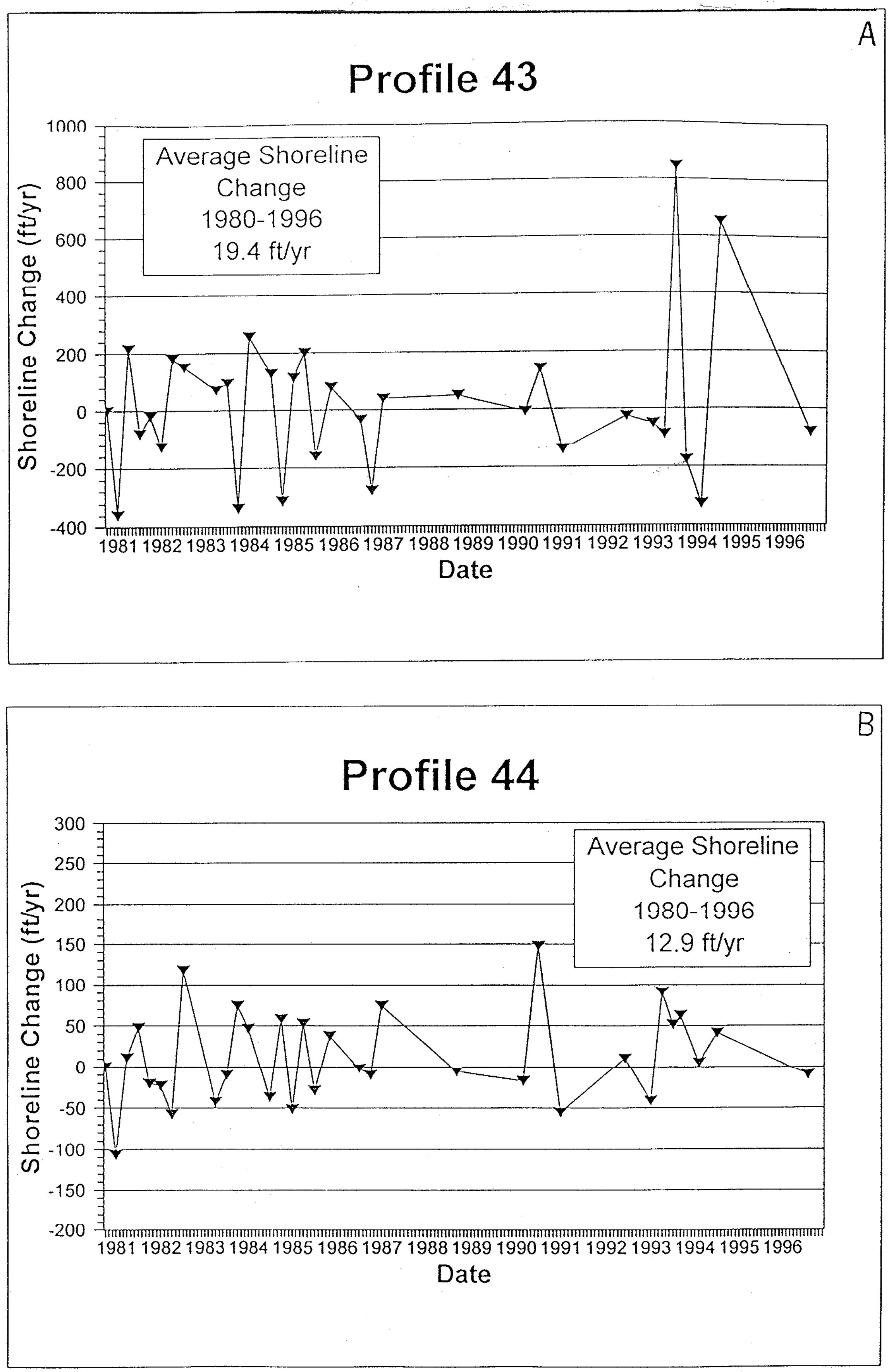
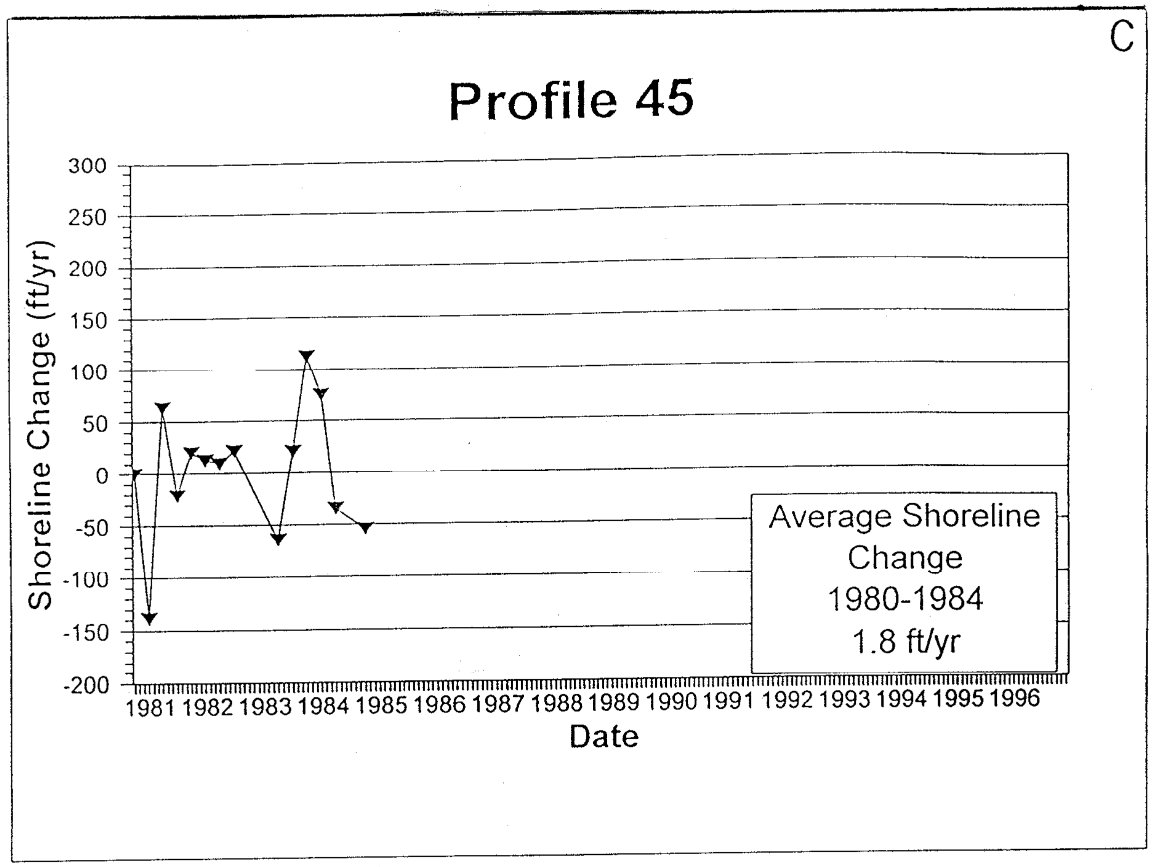


Figure 10. Rate of shoreline change for A) profile 43 and B) profile 44.



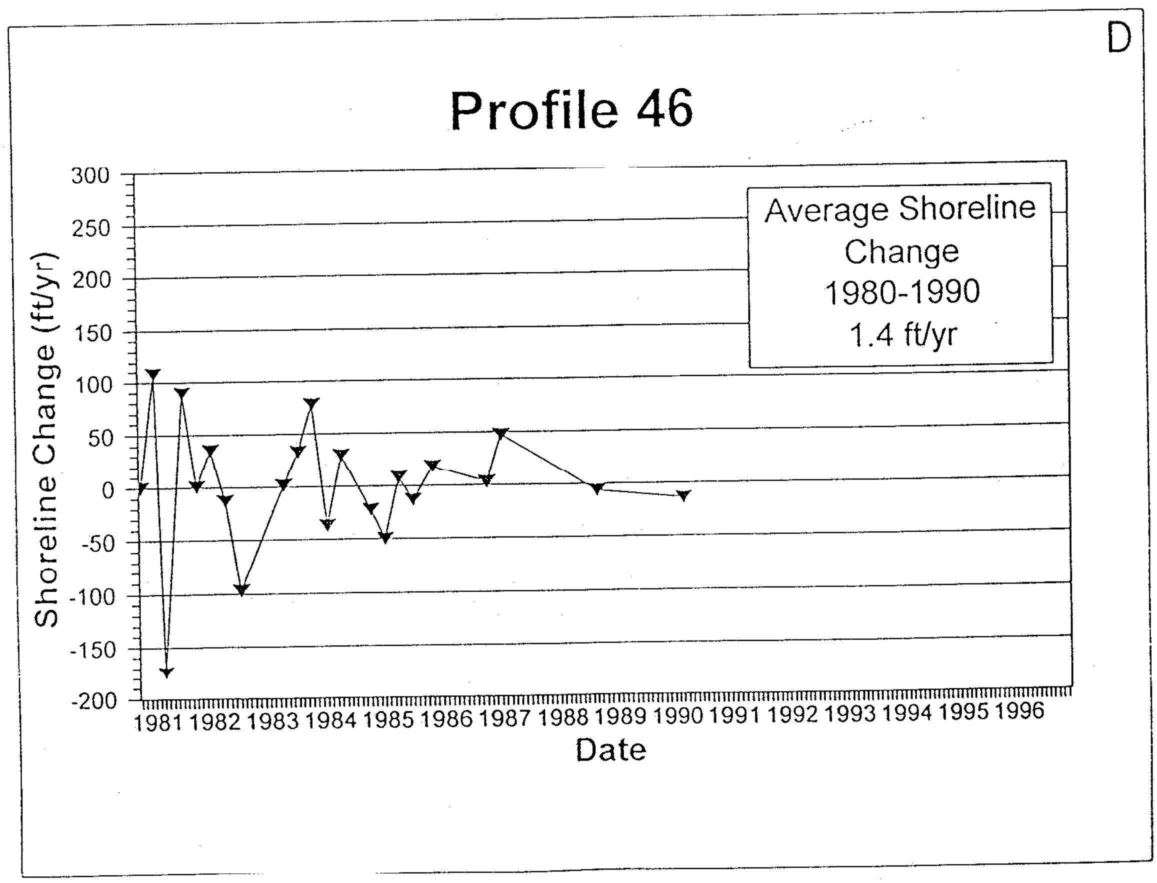
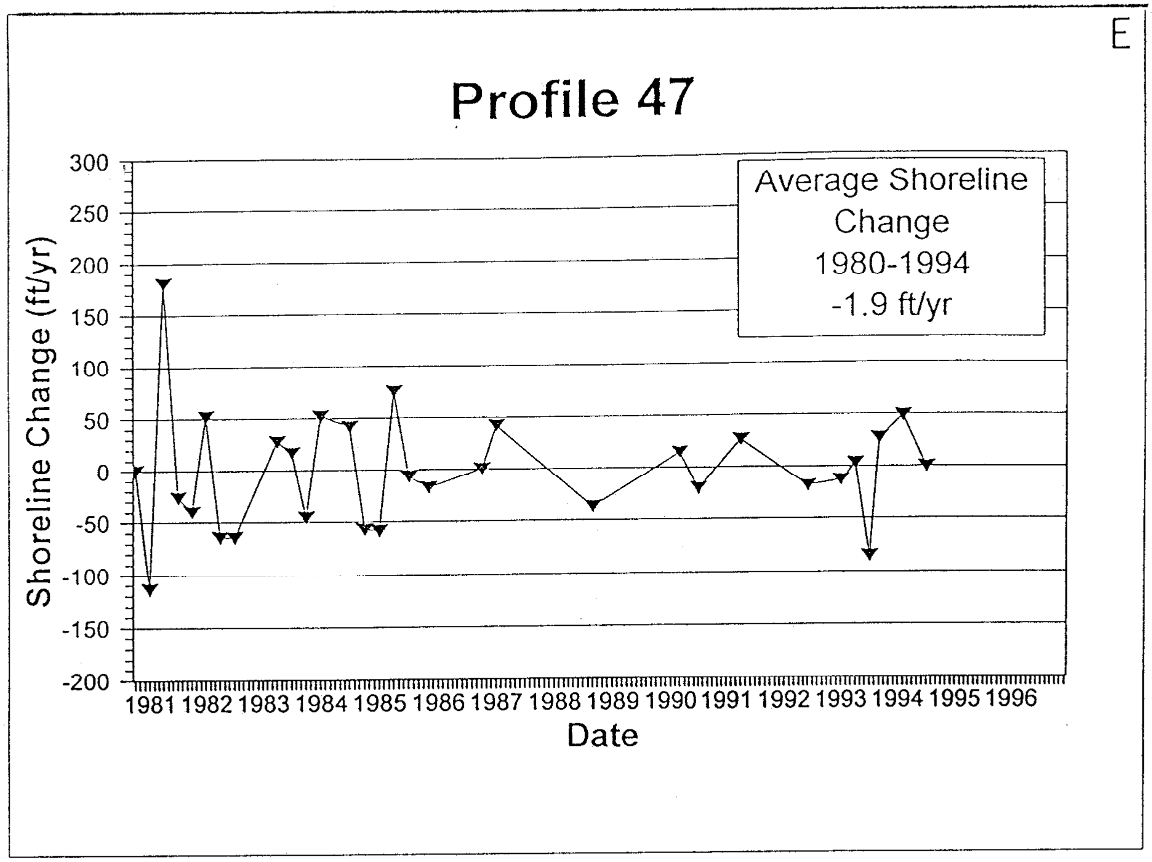


Figure 10. Rate of shoreline change for C) profile 45 and D) profile 46.



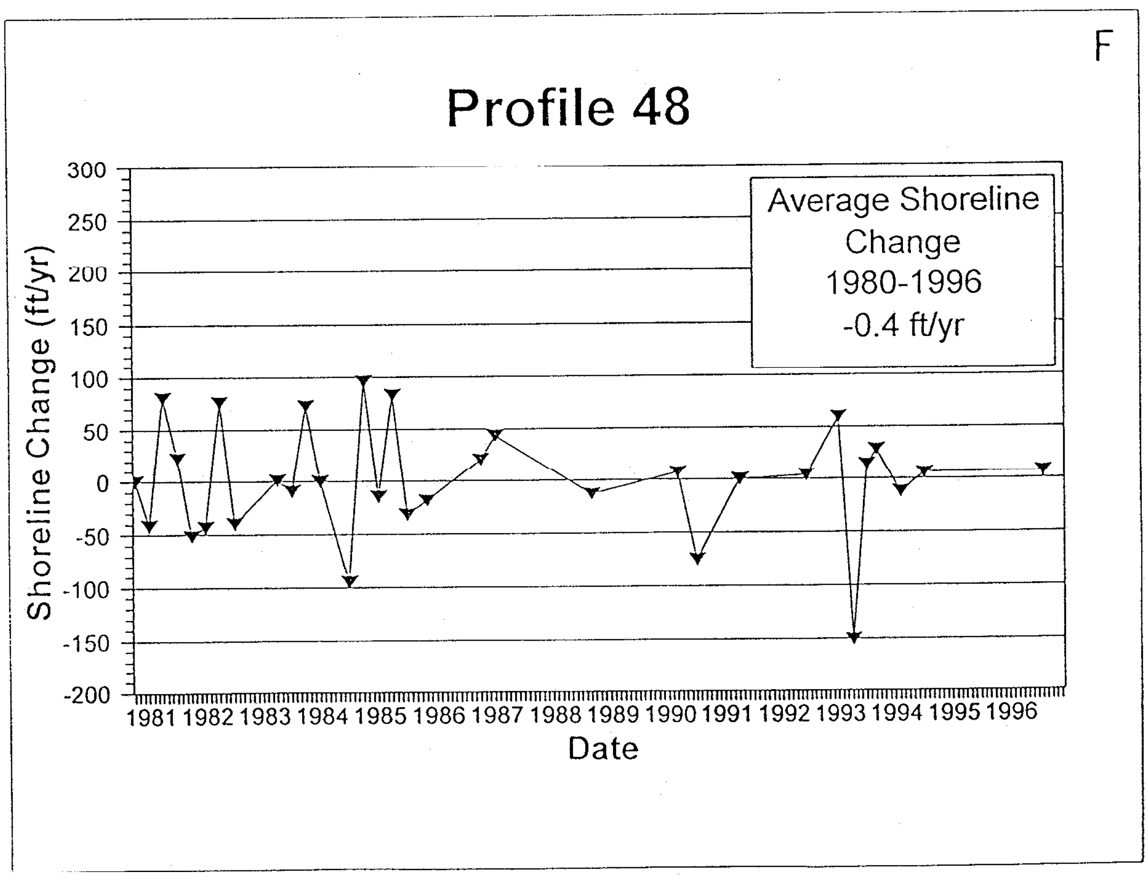
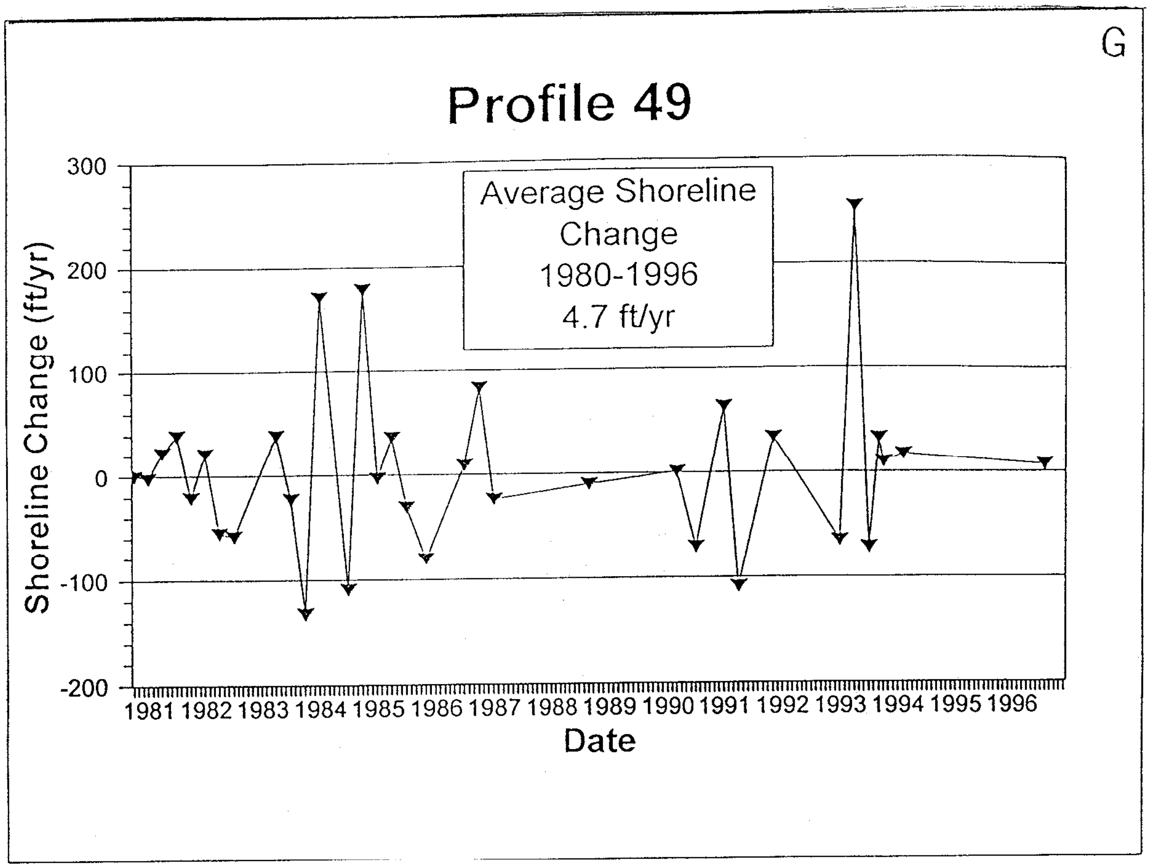


Figure 10. Rate of shoreline change for E) profile 47 and F) profile 48.



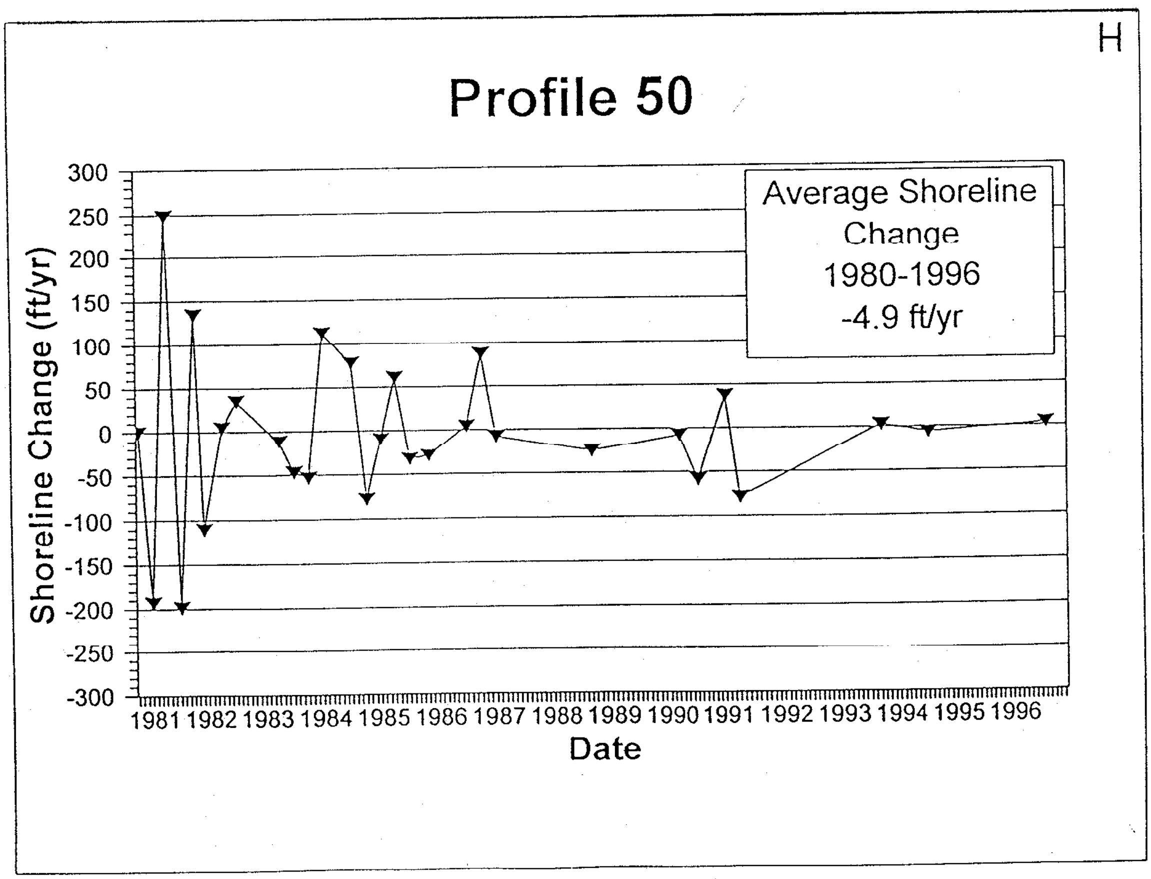
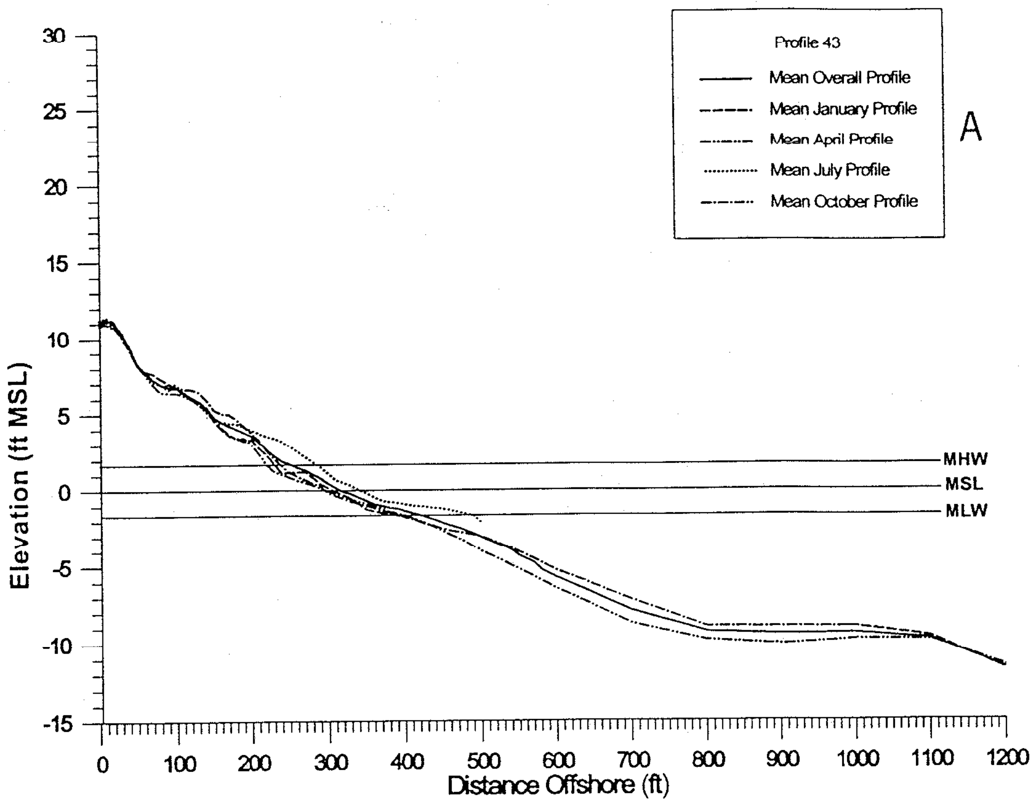


Figure 10. Rate of shoreline change for G) profile 49 and H) profile 50.



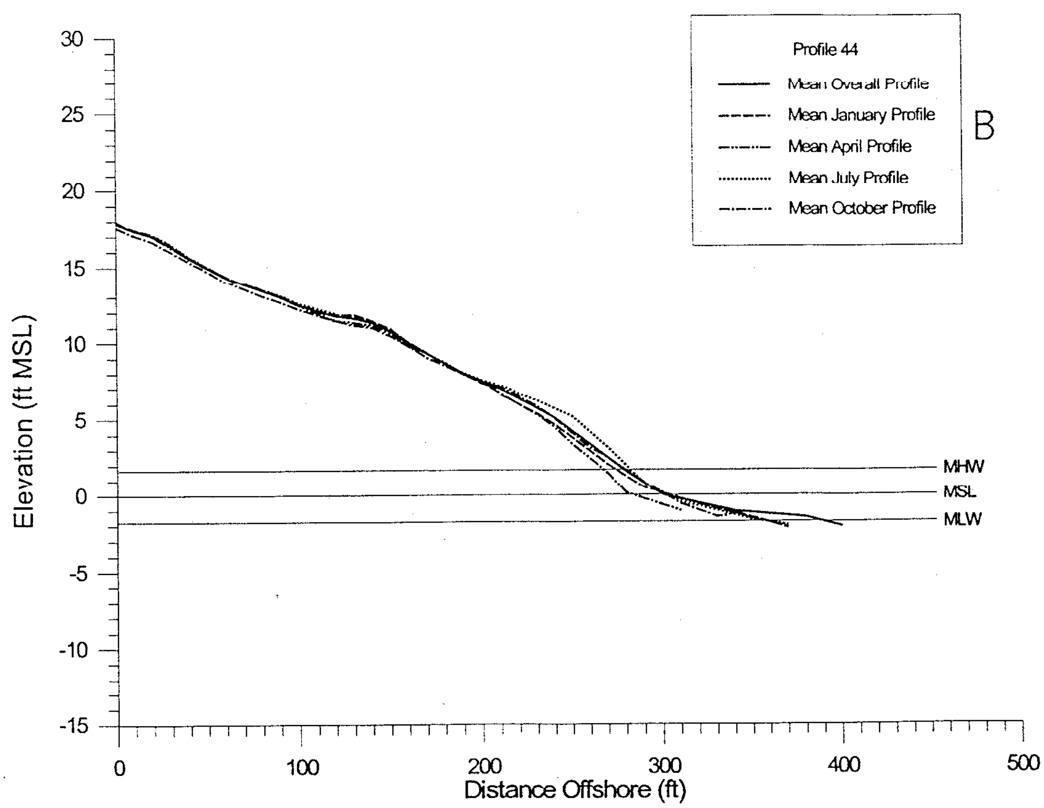


Figure 11. Seasonal changes in A) profile 43 and B) profile 44.

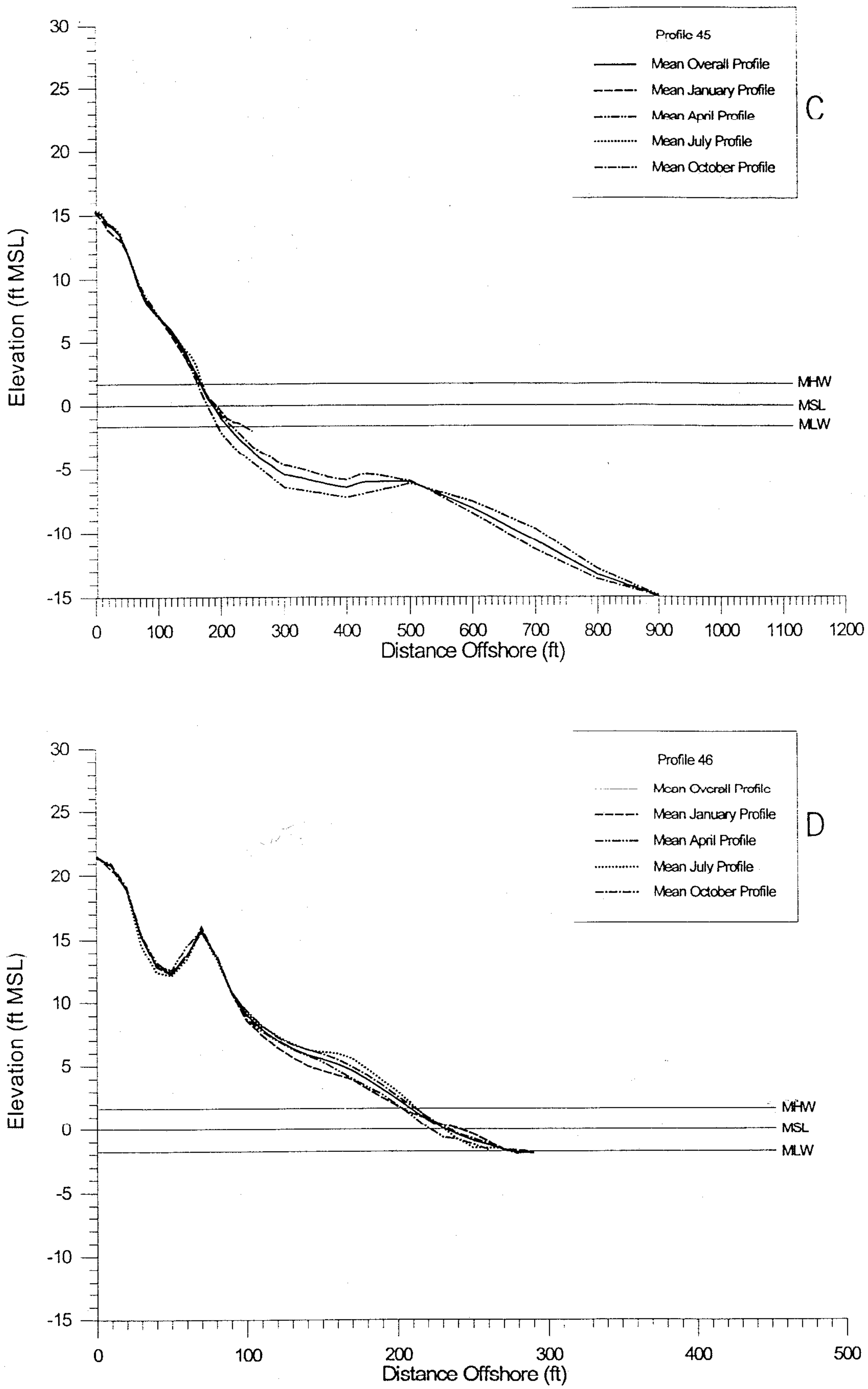


Figure 11. Seasonal changes in C) profile 45 and D) profile 46.

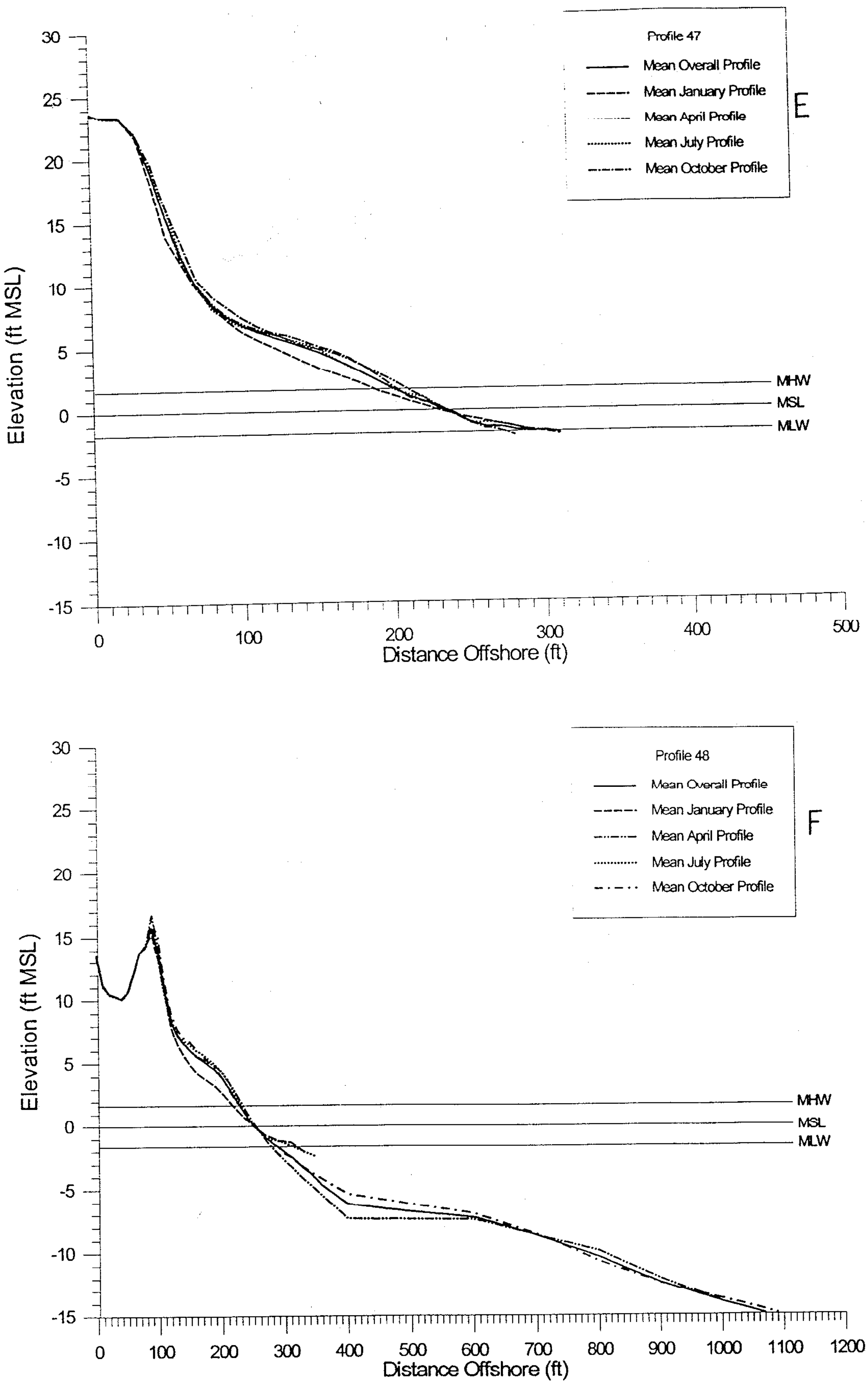


Figure 11. Seasonal changes in E) profile 47 and F) profile 48.

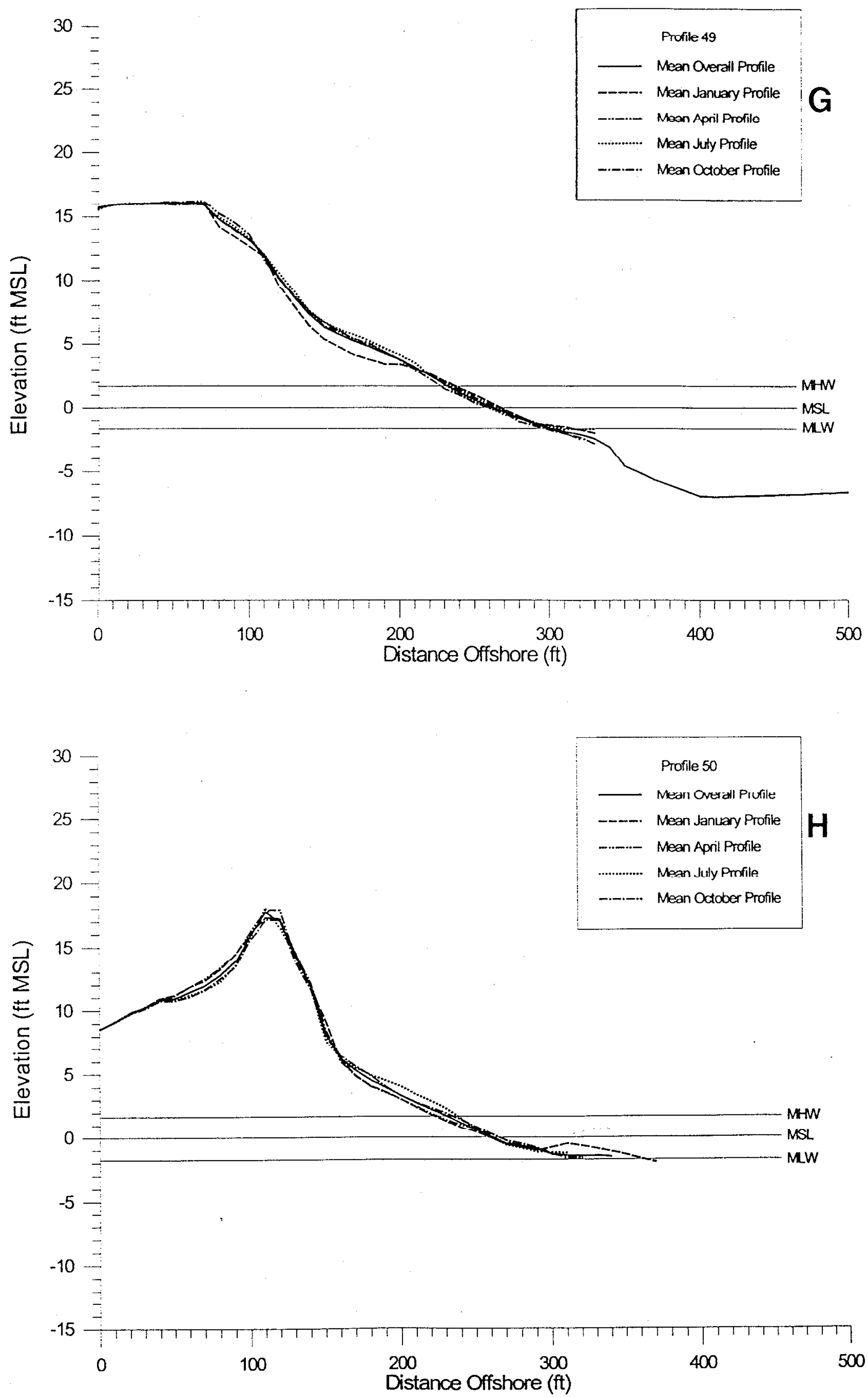


Figure 11. Seasonal changes in G) profile 49 and H) profile 50.

the October profile is higher than the April profile landward of the crossing point. The crossing point occurs at about 10 ft. below MSL at profile 43 (Figure 11A), 6 ft. below MSL at profile 45 (Figure 11C), and at 8.5 ft. below MSL at profile 48 (Figure 11F). The crossing point appears as a berm or bar feature, that is the seaward edge of a lower beach face terrace, and is seaward and deeper than the breaker zone inner bar feature. The sand eroded during the winter appears to be stored further offshore, seaward of the crossing.

Table 3

January	April	July	October
January 19, 1981	April 19, 1981	July 19, 1981	October 19, 1980
January 19, 1982	April 19, 1982	July 19, 1982	October 19, 1981
January 19, 1984	April 19, 1983	July 19, 1983	October 19, 1983
January 19, 1985	April 19, 1985	July 19, 1984	October 19, 1984
January 19, 1987	March 22, 1990	July 19, 1985	November 19, 1985
January 17, 1991	April 10, 1991	July 19, 1996	October 19, 1986
January 14, 1993	April 20, 1993	July 3, 1990	September 28, 1988
February 25, 1994		June 2, 1992	November 21, 1991
		July 9, 1993	September 8, 1993
		July 21, 1994	October 20, 1993
		August 19, 1996	

Survey dates assigned to seasonal groupings.

This feature was recognized by Larson and Kraus (1994) for spring and fall profiles taken at Duck, North Carolina. They called it a pivot point located at about -8.5 ft. water depth. For the southeast ocean coast of Virginia, this may be an outer bar feature since it appears to be persistent through time. The inner bar, usually found toward shore, is difficult to see in the long profiles most likely due to the lack of summer and winter data. Larson and Kraus (1994) found the average depth of the inner bar at Duck, North Carolina to be -5.2 ft. MSL based on 230 bi-monthly profiles. The outer bar crest was less persistent and resided at an average depth of 12.4 ft.. The trend of the inner bar and outer bar is less discernable along this subreach shoreline.

Figures 12A-12H reflect the maximum and minimum profiles for the survey data set as well as the mean profile and standard deviation. The plots for the long profiles (43, 45 and 48) utilize all data until 5 or less points are available offshore. Offshore closure is not reached but can be projected to be between 25 and 30 ft. below MSL. The short profiles generally do not extend below MLW, but most reach a subaerial beach "closure".

The standard deviation is a measure of variability of the profiles. For all the subaerial beach surveys, the common area of vertical excursion occurs in the active swash zone between the beach berm and about MSL; this zone has an average standard deviation of 1.7 ft. Profiles 46, 48,

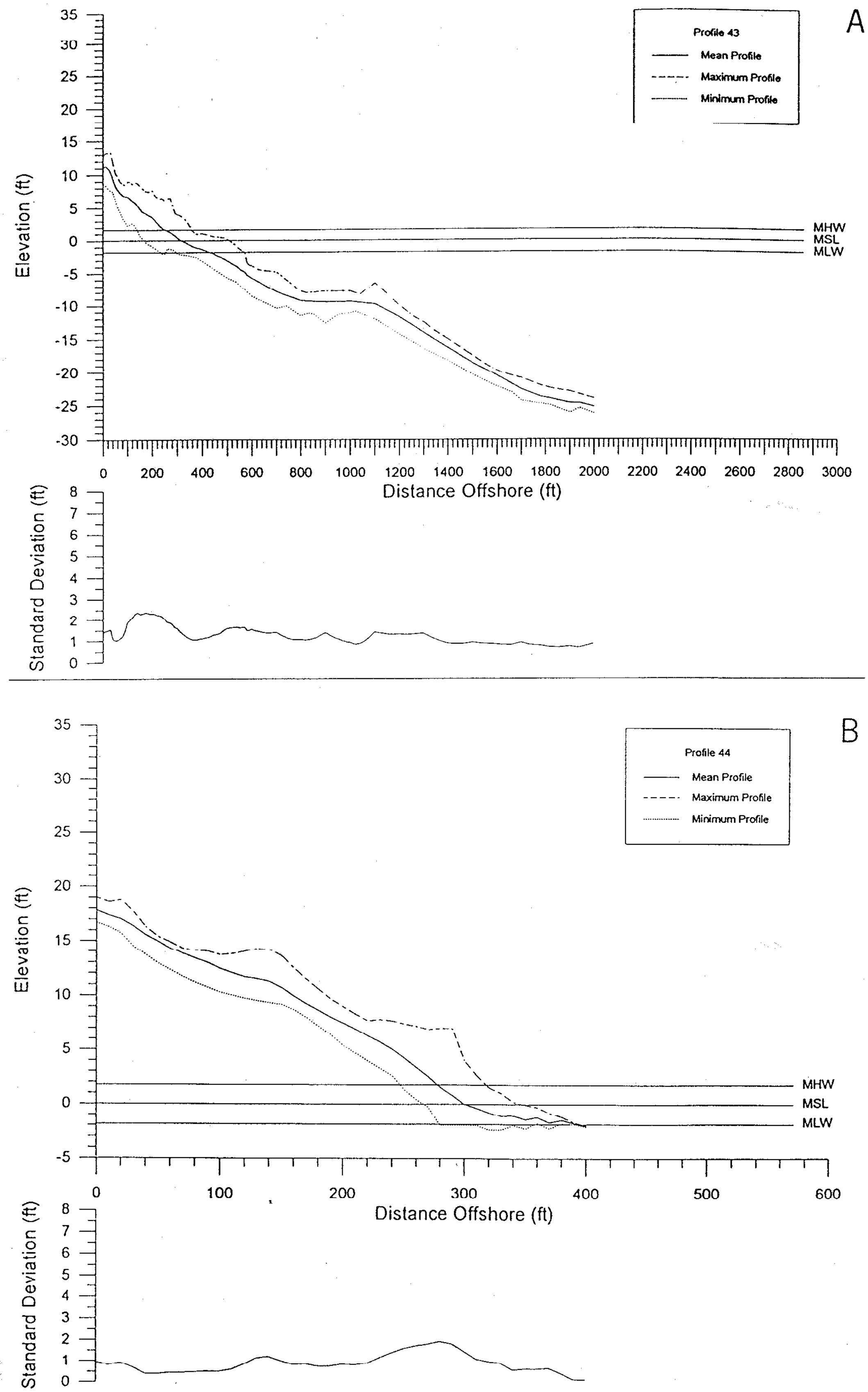


Figure 12. Maximum, minimum, and mean plots, with standard deviation, for A) profile 43 and B) profile 44.

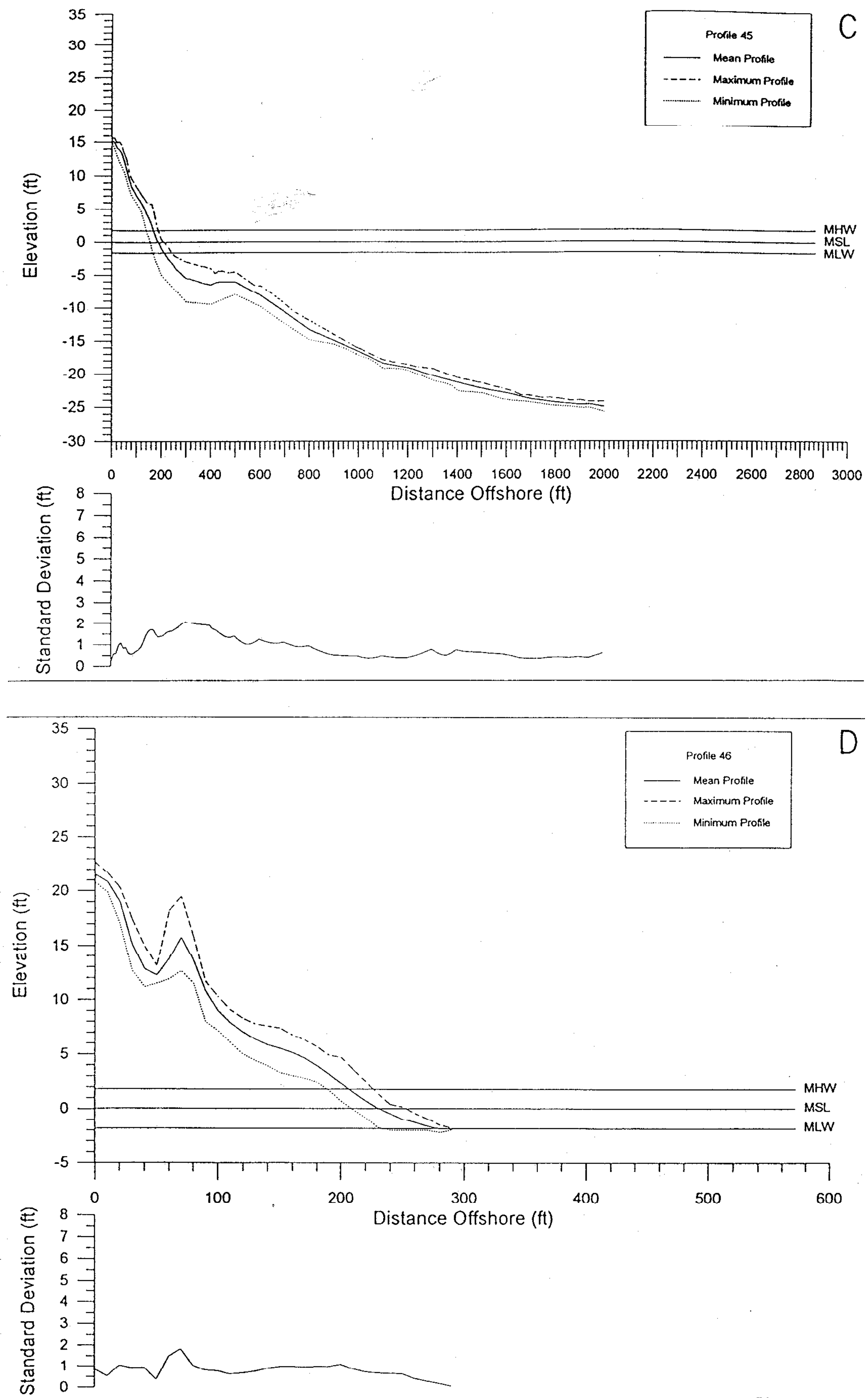
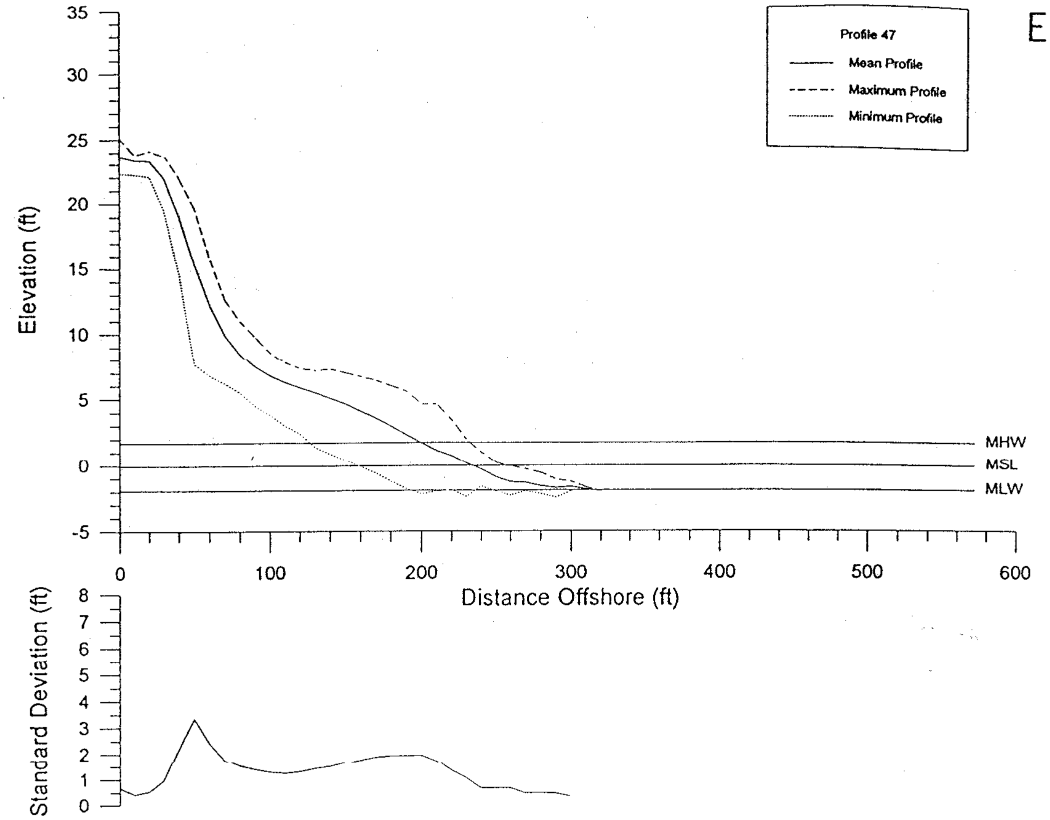


Figure 12. Maximum, minimum, and mean plots, with standard deviation, for C) profile 45 and D) profile 46.



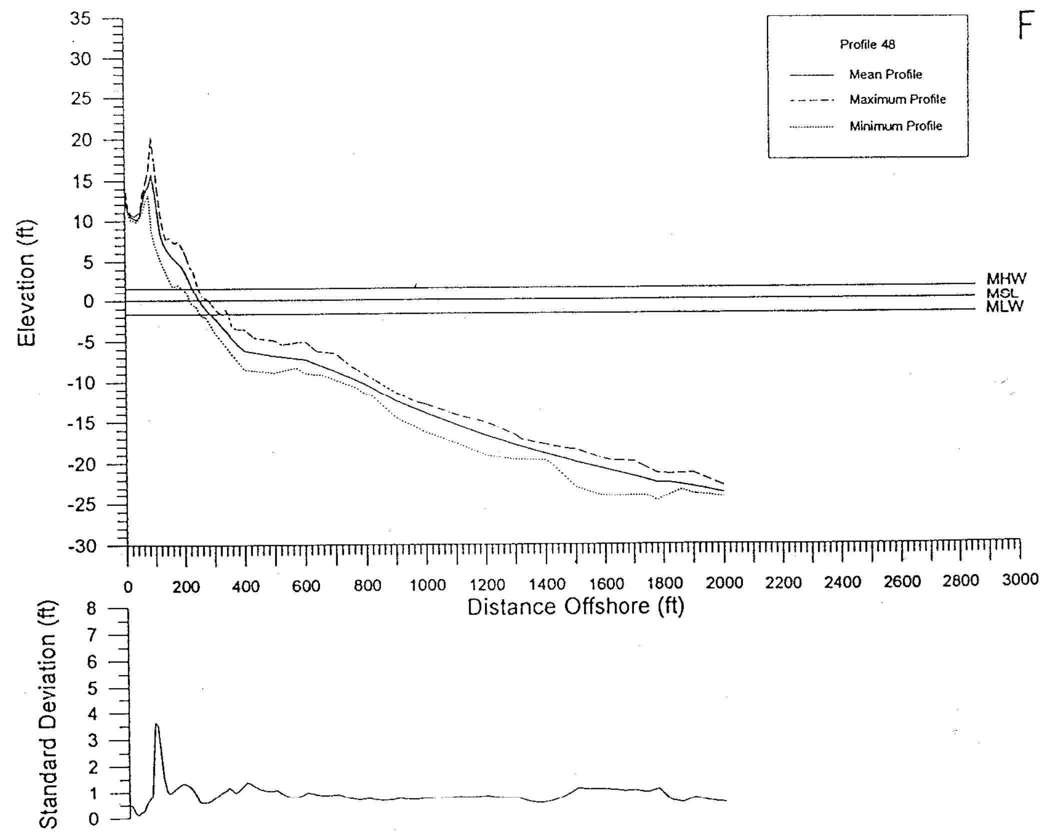
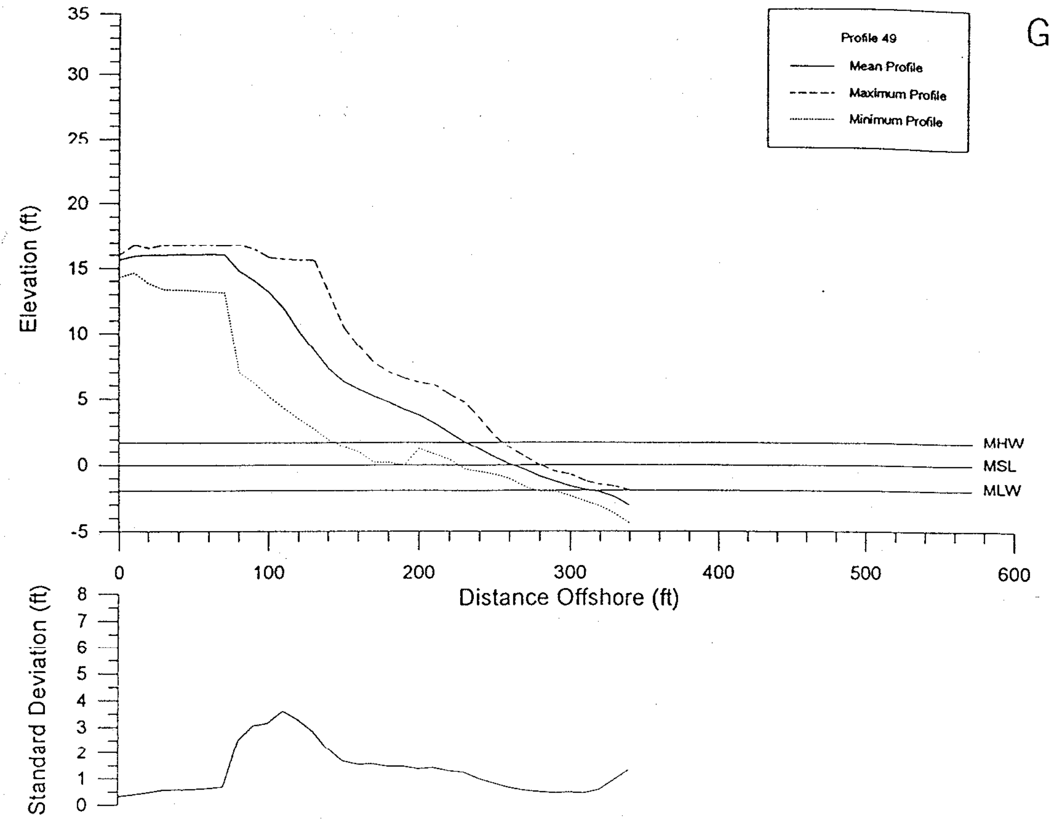


Figure 12. Maximum, minimum, and mean plots, with standard deviation, for E) profile 47 and F) profile 48.



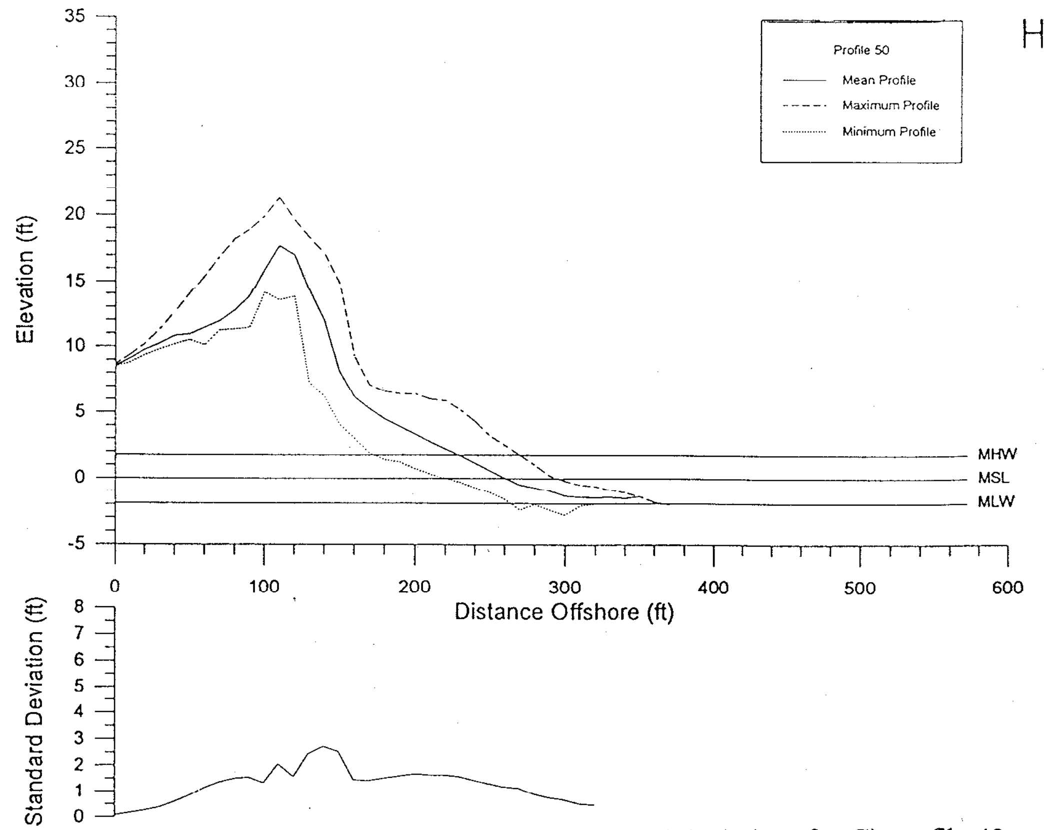


Figure 12. Maximum, minimum, and mean plots, with standard deviation, for G) profile 49 and H) profile 50.

49 and 50 show significant fluctuations in the foredune. Vertical changes in the base of dune have a standard deviation of 3.4 ft. on profile 47. The average standard deviation for the dune face for all profiles is 2.6 ft. (Table 4).

For the maximum, minimum and mean analysis of the long profiles (43, 45 and 48), the offshore bar/terrace feature (pivot point) seen in the seasonal profiles is once again apparent. The area of the largest vertical profile excursion along the offshore segment occurs landward of the pivot point at the base or toe of the beach face. Standard deviations and depths of the toe of the beach face are shown in Table 4.

Table 4

Profile	Beach Berm	Dune Crest/Face/Base	Toe of Beach Face
43	2.4	1.5	1.6 = Standard Deviation Depth = -4.0 ft
44	1.9		
45	1.7	1.2	2.0 = Standard Deviation Depth = -5.5 ft
46	1.2	1.9	
47	2.0	3.4	
48	1.4	3.7	1.4 = Standard Deviation Depth = -6.5 ft
49	1.5	3.6	
50	1.8	2.7	
Average	1.7	2.6	

Standard deviation (ft.) of selected beach features resulting from the maximum, minimum, and mean analysis.

Dam Neck Beach Nourishment Project, 1996-1997

The DNBNP came online after this study was geared toward a profile and sediment analysis of the Sandbridge shore subreach. It was decided to take advantage of this opportunity to track the movement of the beach nourishment for one year. Sampling of the beach and nearshore region was performed to note significant changes in profile trends and sedimentology. The eight aforementioned City profiles were chosen as reference lines for this evaluation. Surveys and samples were performed prior to the DNBNP (August 1996), about 6 months after the project (May 1997) and after about one year (October/November 1997). The one year sampling took two days. The beach and dune were surveyed and sampled in October 1997 while the offshore work was not accomplished until November 1997. Between the two sampling dates, a moderate northeaster occurred (October 15 to 19) and impacted beach morphology and offshore sedimentation processes. Also, City profile data was used for the August 1996 profile plots;

however, no City data was available for profiles 45 and 46 so the mean summer profile was used for the August 1996 date.

The following discussion of analyses resulting from VIMS's one-year monitoring will be separated into 1) the subaerial beach and nearshore surveys, and 2) the sediment sampling and its analysis. Most of the historic shore change data and much of the City's profile data only covers the "subaerial" beach zone, but some City profile data covers the upper shoreface, an area that will be impacted by the DNBNP.

Subaerial Beach and Nearshore Surveys

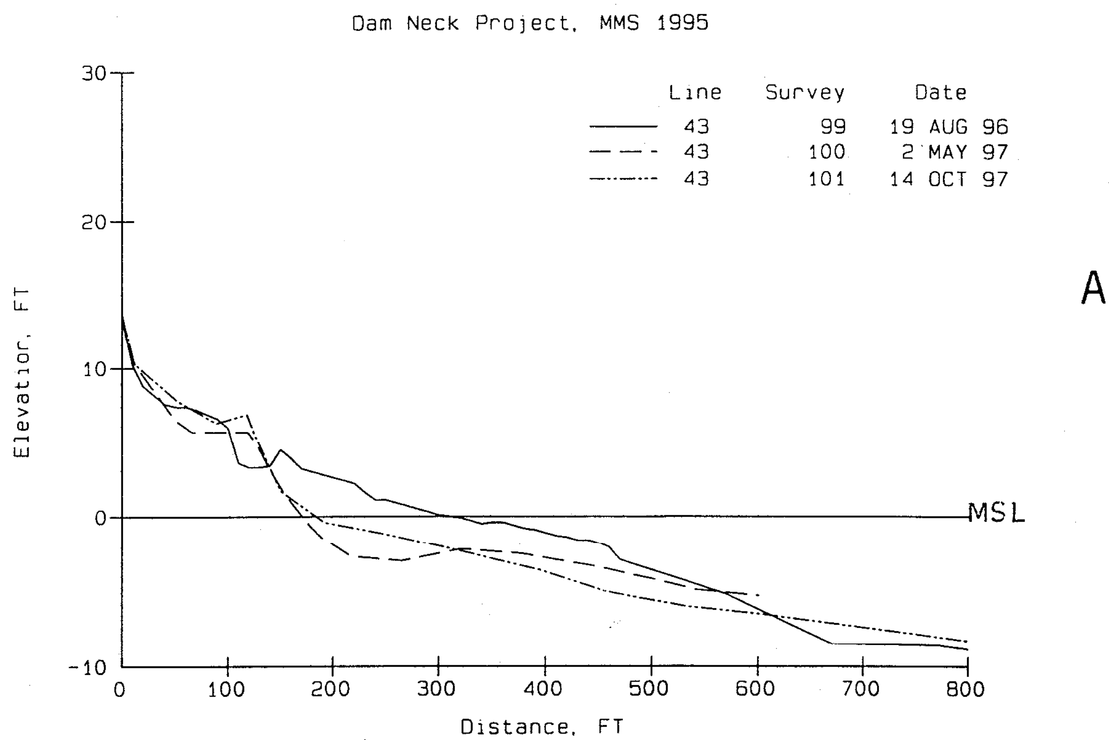
Profile plots of the three sampling periods include the subaerial beach and nearshore (Figures 13-20). The subaerial beach may be defined as that area of the profile from about MSL to the dune crest. Two plots are posted for each profile to better see the beach. The nearshore portion of the profile is what lies below MSL. Two nearshore profiles include August 1996 and November 1997. When City data was not used (i.e. their short profiles), the bathymetry was determined by the coordinates at the sediment sample location (Appendix A). The beach and nearshore surveys were done on separate days for the data taken one year after the initial fill project. For this nearshore survey, the profile from 6 ft. below MLW seaward was taken in November 1997 but is plotted with the subaerial beach (data taken in October 1997); the following plots show data from both dates, even if October 1997 is the date on the plots.

There is considerable upper profile variability on profile 43 (Figure 13A and 13B) that is most likely attributable to Rudee Inlet, which acts as a littoral barrier, and the associated dredging. Dredging was being done during the May 1997 survey. Vertical changes are most significant between about +5 ft. MSL and -10 ft. MSL. A general loss of material form the beach and very nearshore occurred between August 1996 to October 1997; however, during that time, there also was an increase in beach berm elevation. Below the -7 ft. contour, there was a net increase of sand volume between August 1996 and October 1997.

Heavy equipment was pushing sand around the backshore at profile 44 (Figures 14A and 14B) during the May 1997 survey. This activity modifies the natural patterns of profile change along the subaerial beach zone. The subaerial beach berm grows in elevation and becomes an obvious feature on the profile by October 1997. Profile 44 acquires an inner bar in May 1997 and October 1997 and what may be a "pivot" point occurs about 1,000 ft. on the survey line at about 10 ft. below MSL. Profile 44 was historically a short profile in the City's data set.

Profile 45 (Figures 15A and 15B), a long City profile with a data set that only extends four years, lies about mid-way between profiles 44 and 46. Subaerial beach changes indicate beach berm and beach face growth. Nearshore erosion occurred down to the -4 ft. contour from August 1996 to May97 but then an accretionary trend occurred by October 1997 with bar growth occurring 380 ft. offshore.

Profile 46 (Figures 16A and 16B) is located about 1000 ft. north of the limit of beach fill associated with the DNBNP. The October 1997 survey shows an accretionary trend of the beach berm (Figure 16A) and a general profile decrease across the nearshore segment of the profile



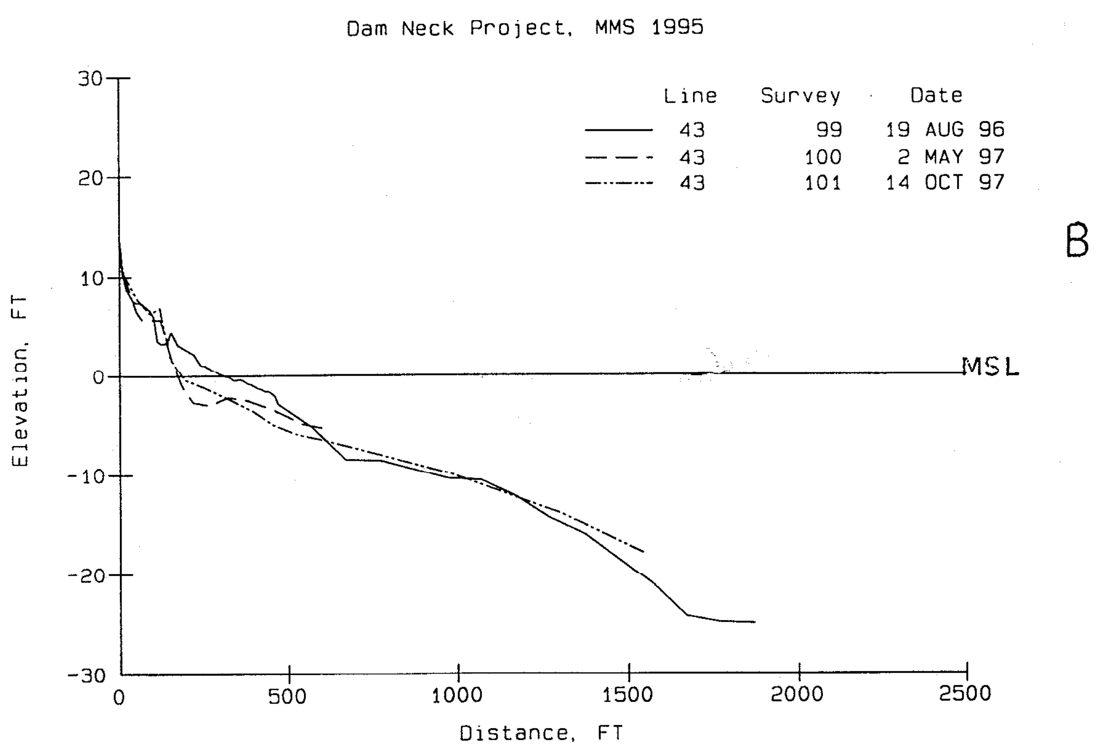
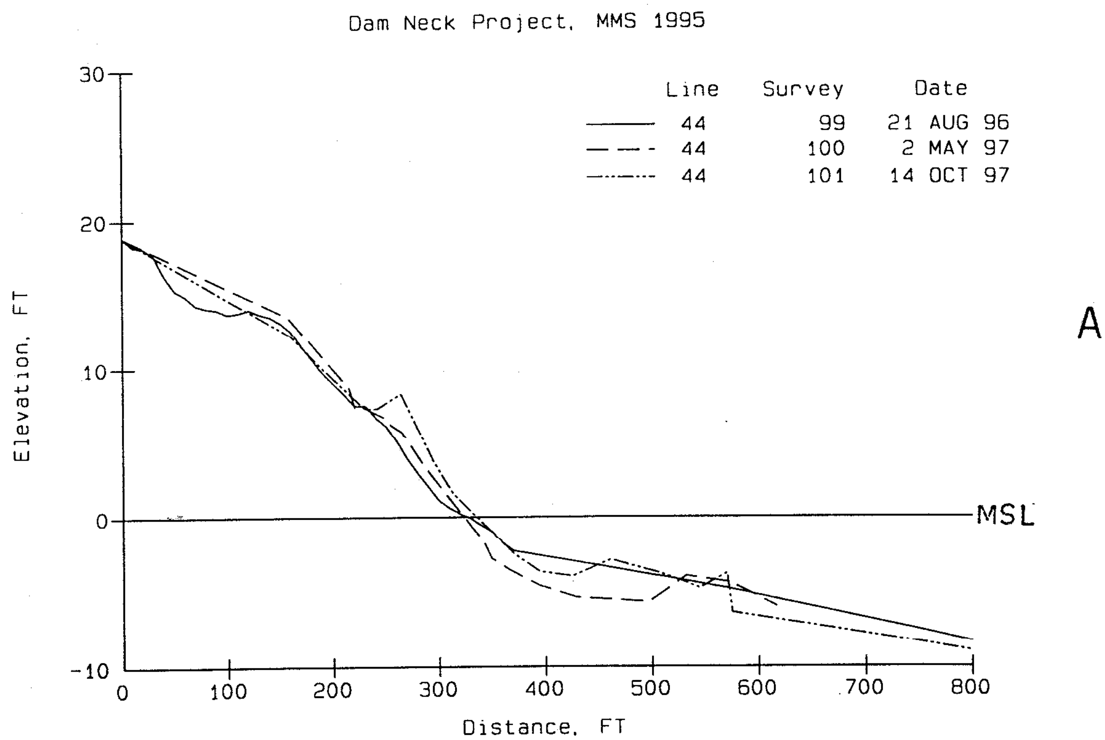


Figure 13. Profile 43 A) subaerial beach plot and B) long profile plot.



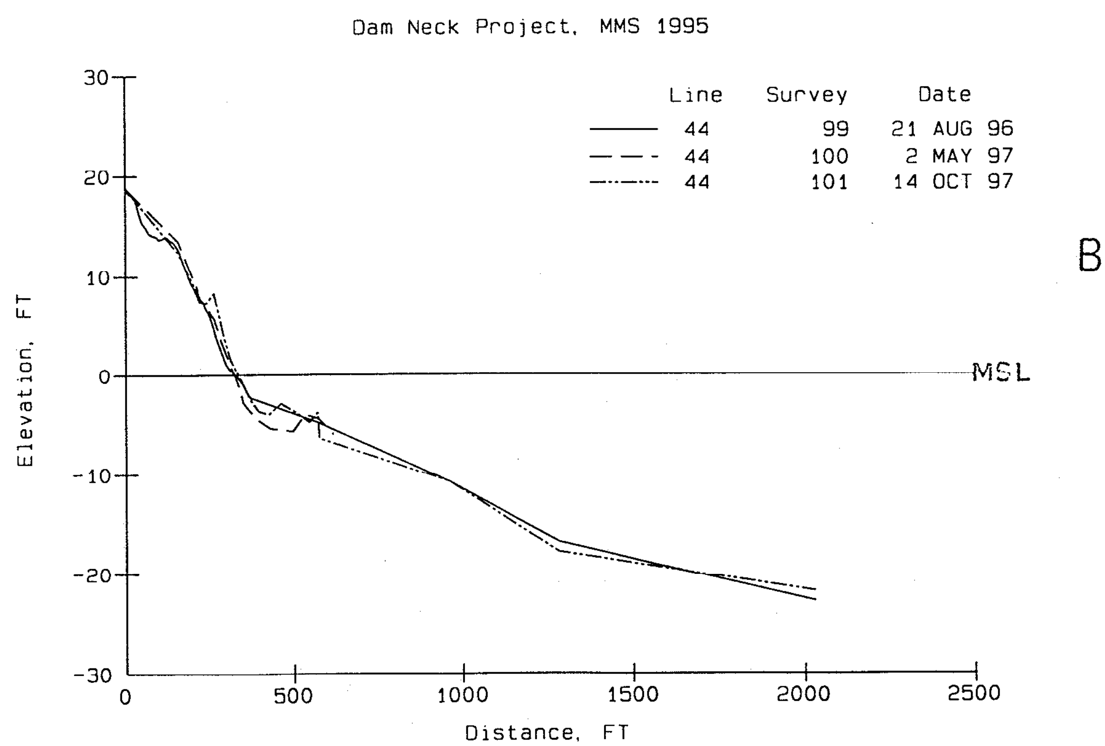
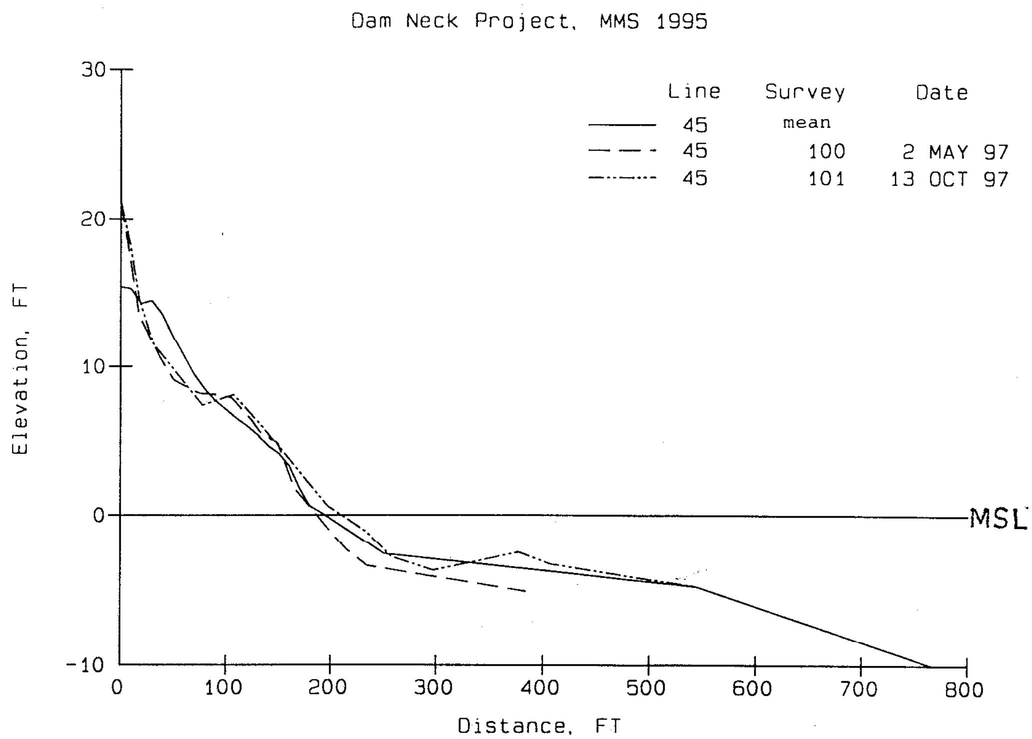
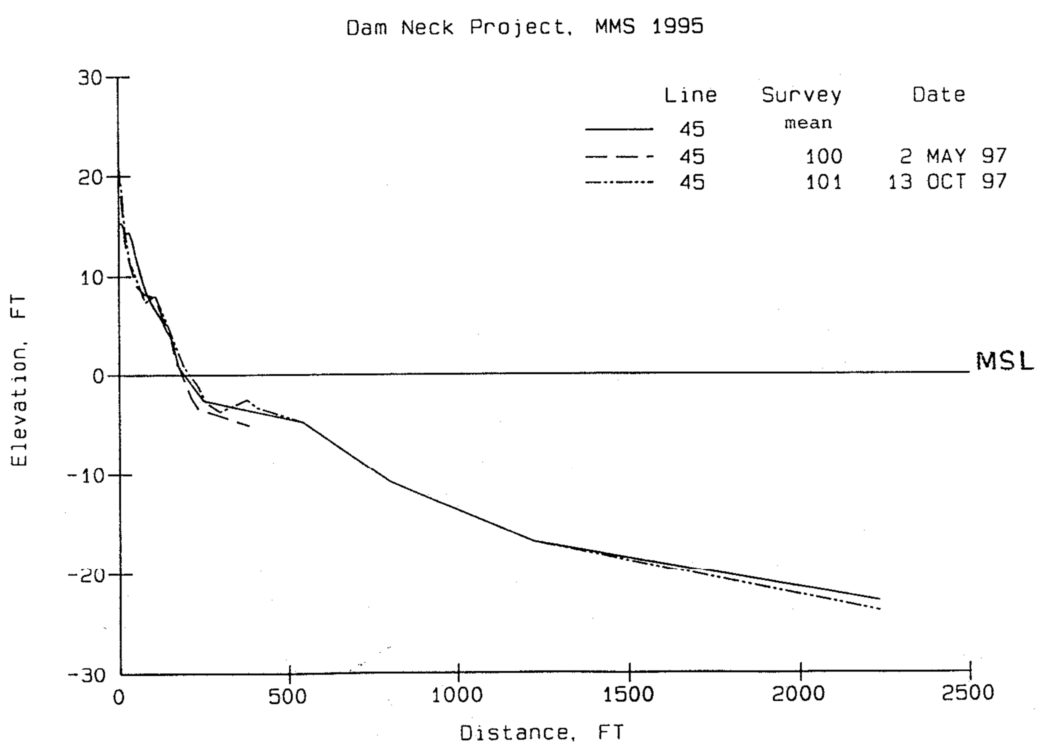


Figure 14. Profile 44 A) subaerial beach plot and B) long profile plot.

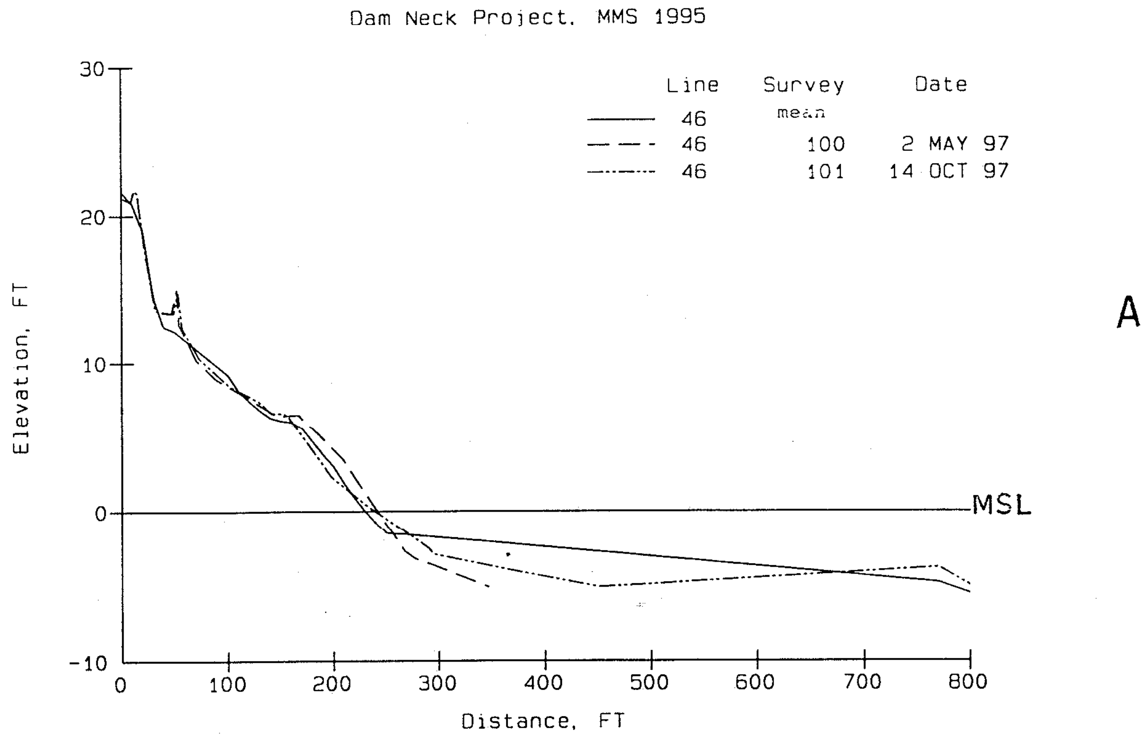


A



B

Figure 15. Profile 45 A) subaerial beach plot and B) long profile plot.



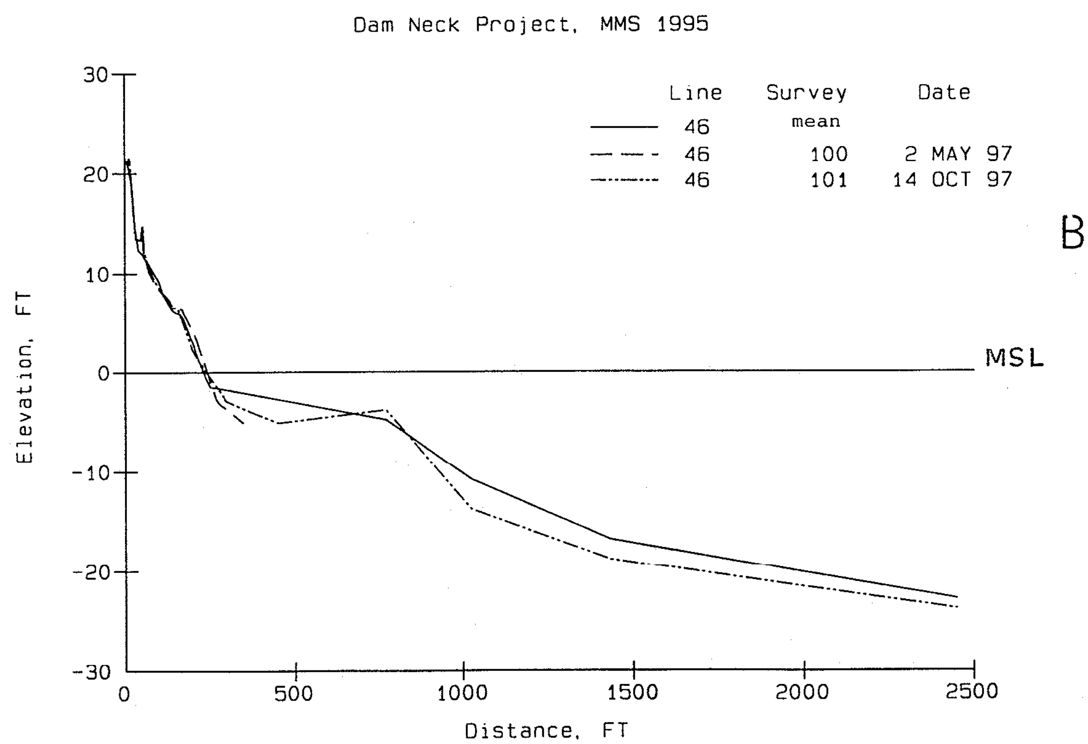
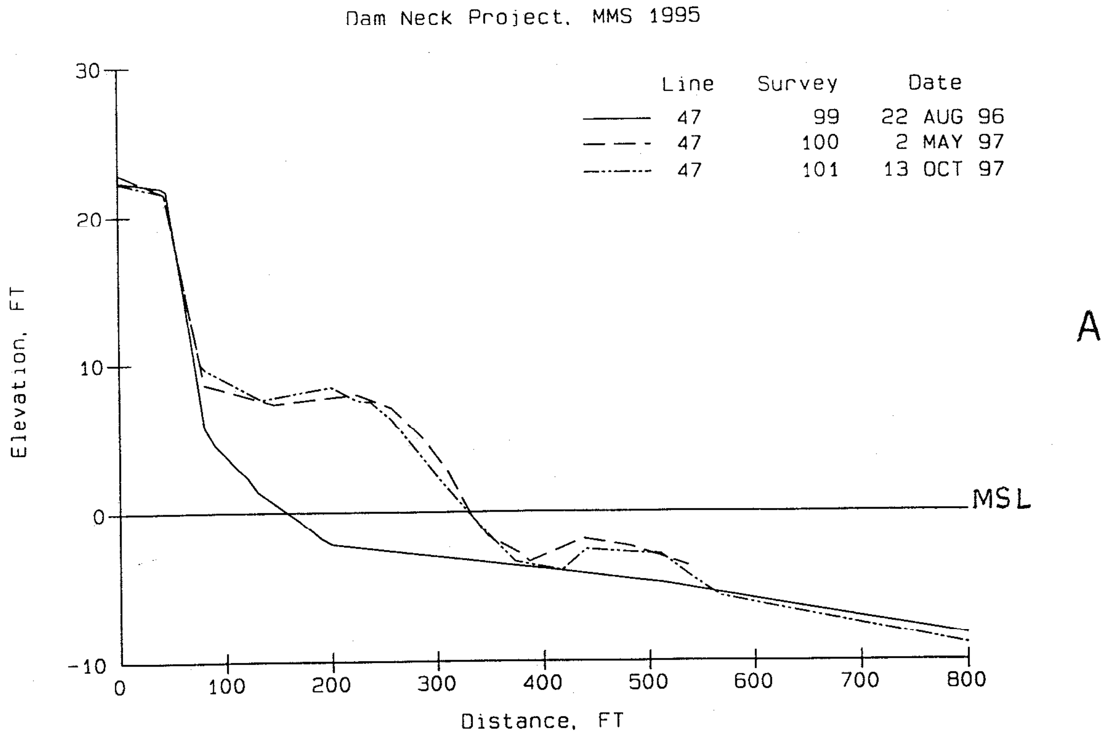


Figure 16. Profile 46 A) subaerial beach plot and B) long profile plot.



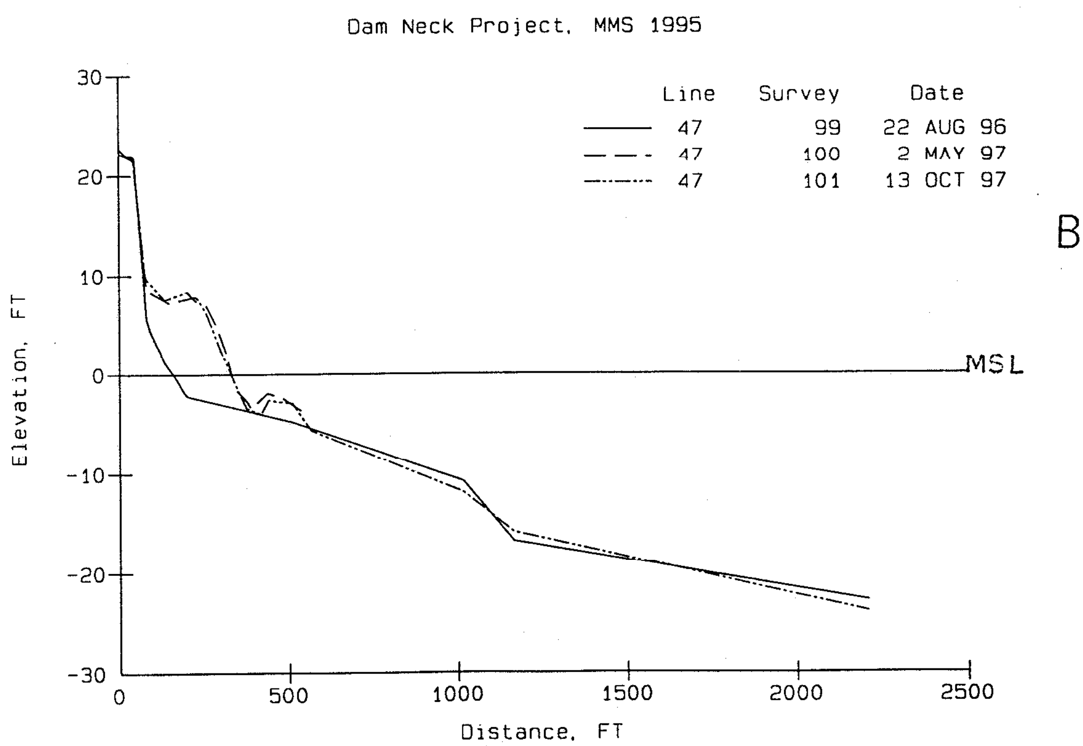
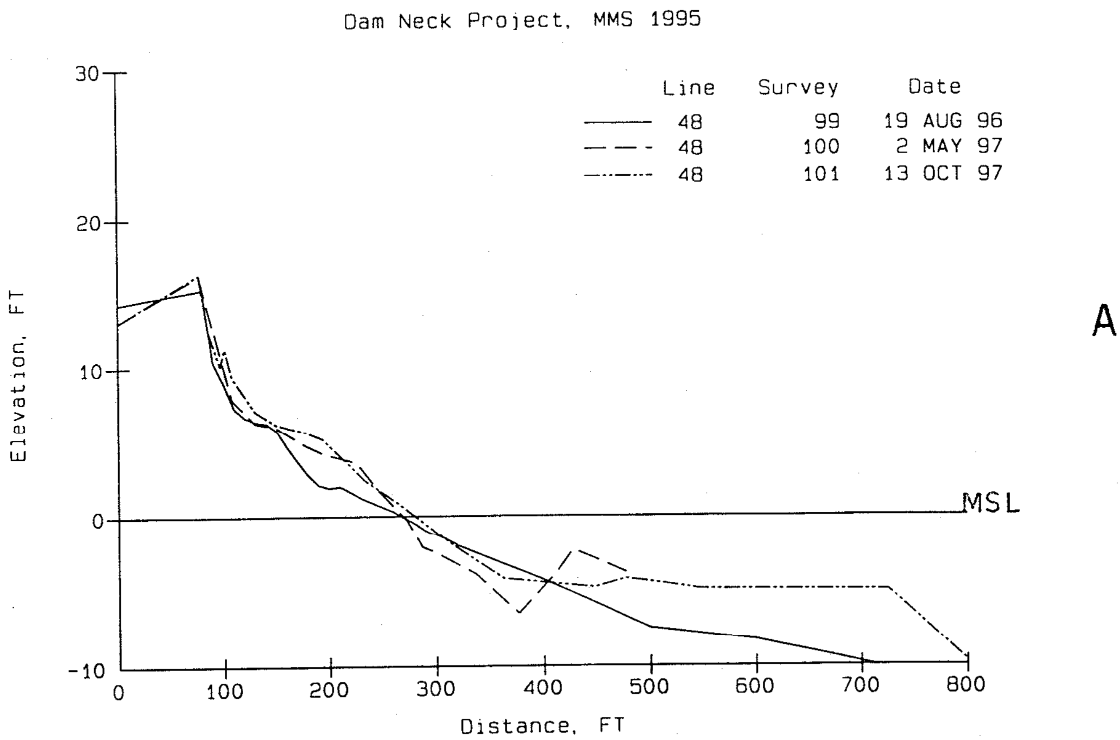


Figure 17. Profile 47 A) subaerial beach plot and B) long profile plot.



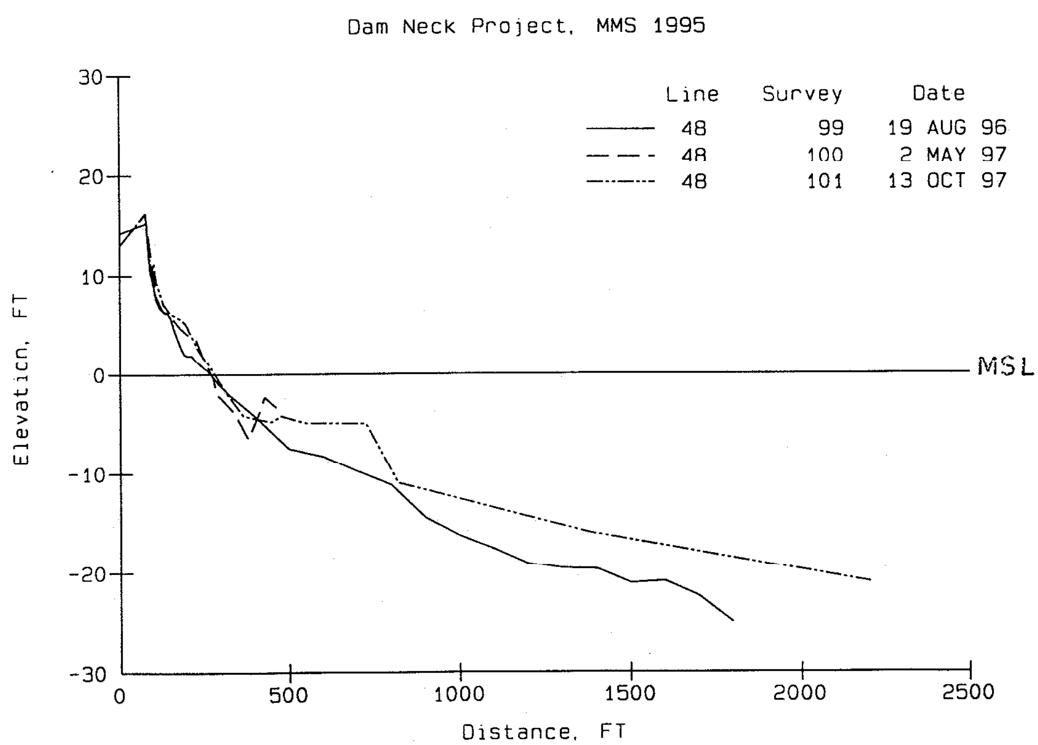
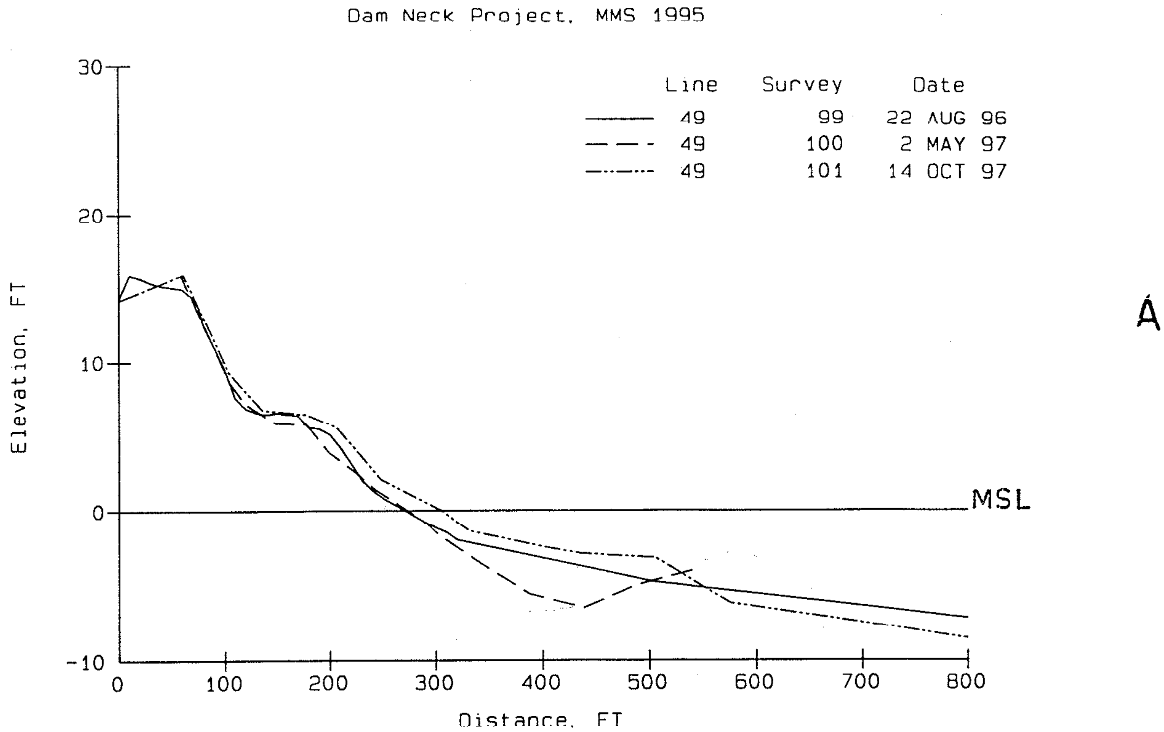


Figure 18. Profile 48 A) subaerial beach plot and B) long profile plot.



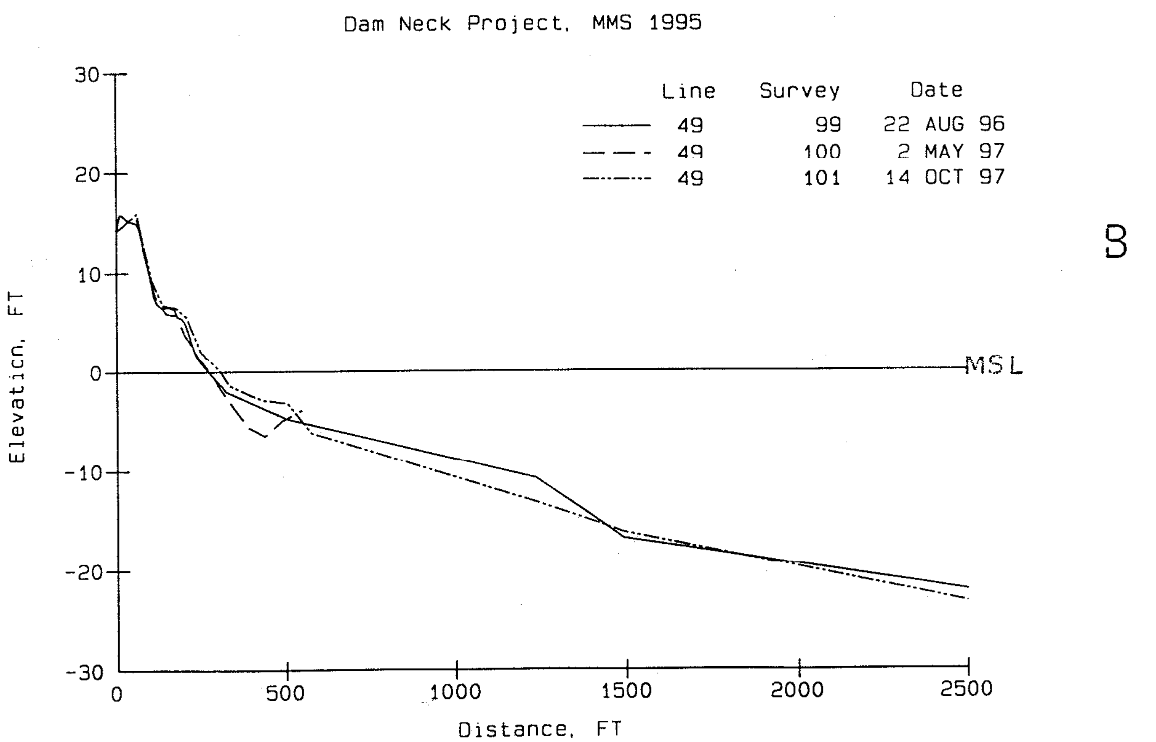
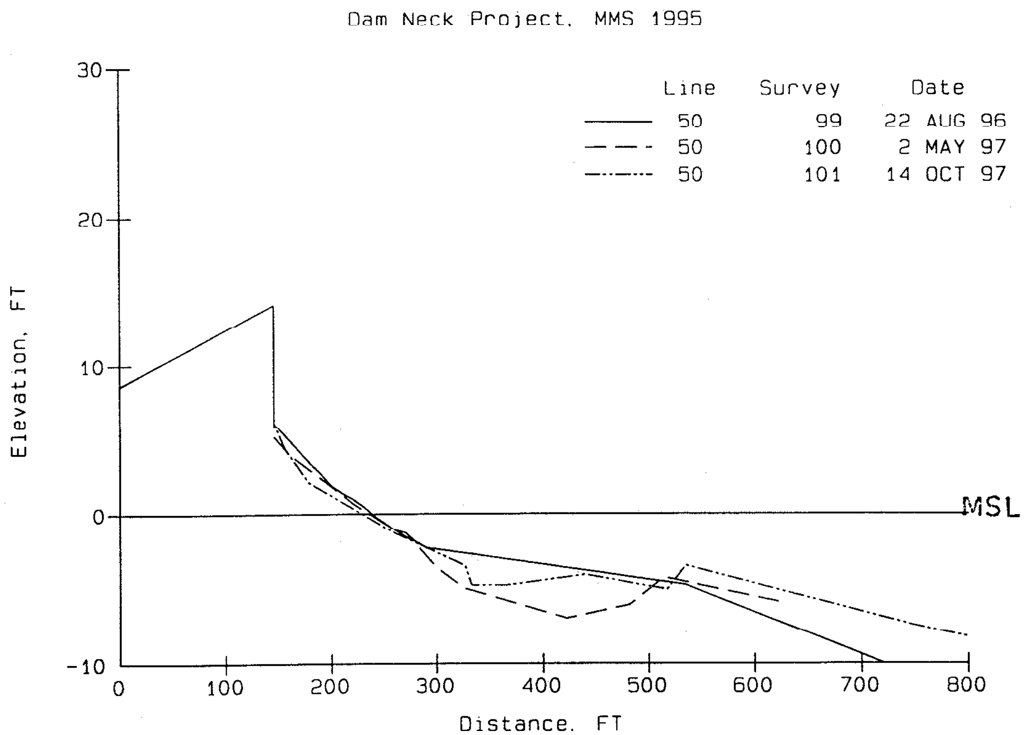
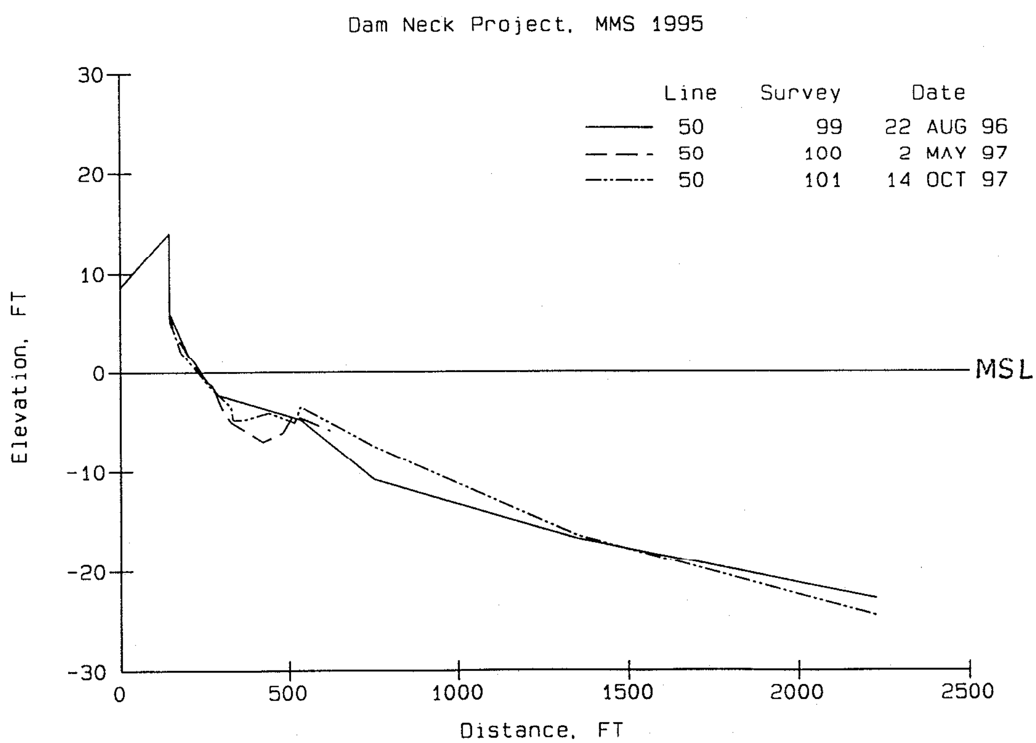


Figure 19. Profile 49 A) subaerial beach plot and B) long profile plot.



A



B

Figure 20. Profile 50 A) subaerial beach plot and B) long profile plot.

(Figure 16B). This offshore change may reflect the storm (October 1997) wave interaction with the beach fill mass to the south where wave refraction might scour the shoreface at that point.

Profile 47 is located at about the middle of the beach nourishment project, and the beach fill berm is quite obvious in Figures 17A and 17B. Initial landward adjustments to the beach face and inner bar is evident between surveys May 1997 and October 1997 as is some washover and base of dune accretion. The inner bars appear to have developed off the face of the adjusting beach fill. Changes further offshore do not appear to be significant, even after several days of northeaster waves. A slight cut and fill relationship occurred at about the -10 ft. MSL contour between August 1996 and October (November) 1997.

Figures 18A and 18B show profile 48 which is located about 2,000 ft. south of the southern limit of the DNBNP. A progressive, accretionary beach berm is shown between May and October 1997 surveys, and sand volume significantly increases below MSL. This may reflect a response of the upper shoreface to the Oct 15-19 northeaster. The data imply that there was a southward flow of material from the beach fill mass along the subaerial and offshore segments of the south bound area.

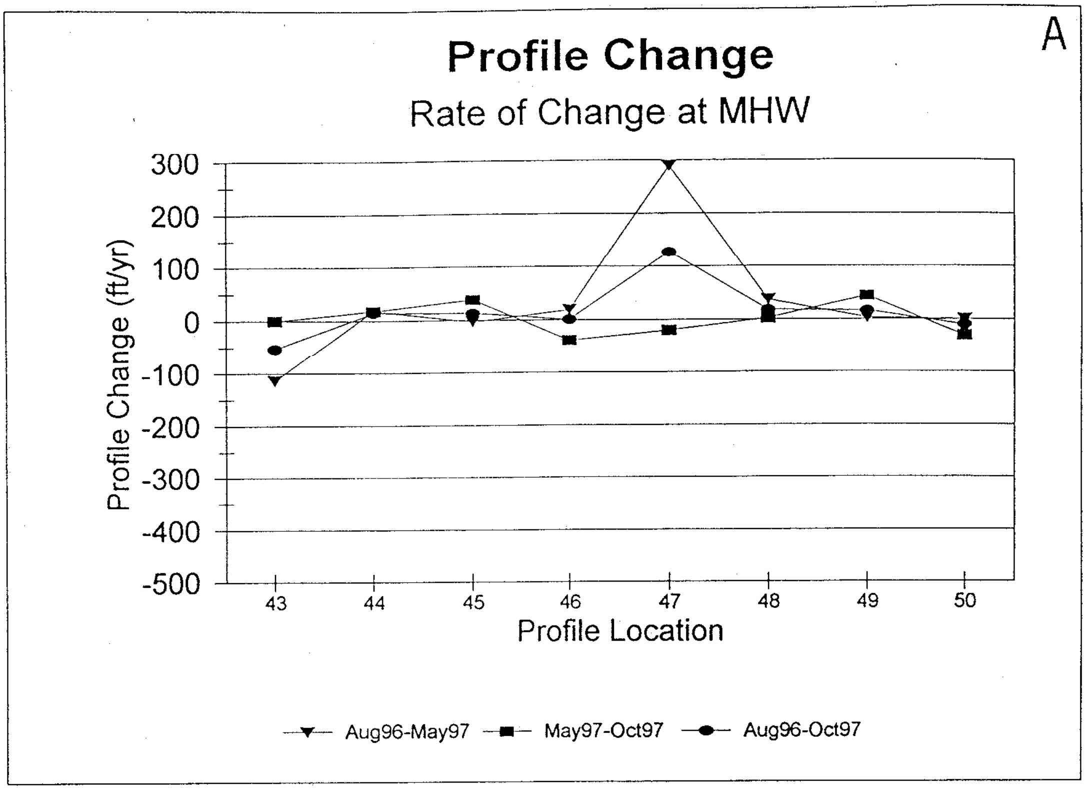
Continued accretion of the subaerial beach and nearshore from about +5 ft. MSL to -4 ft. MSL is noted in profile 49 (Figures 19A and 19B). A bar is located at the offshore limit of accretion, and net profile erosion occurs out to the -16 ft. MSL contour. Profile 49 appears to have a southward movement of the beach fill along the subaerial and very nearshore profile segments but not further offshore.

This is an erosional trend of the beach face in front of the bulkhead at profile 50 (Figures 20A and 20B). An inner bar and trough develops in the May 1997 and October 1997 surveys. Between August 1996 and October 1997, an accretionary trend tapered seaward from the inner bar feature offshore to about the -16 ft. MSL contour. Beyond that there is a slight erosional trend toward the seaward end of the profile.

The above profile trends are summarized by plotting the rate of change in the lateral position of MHW and the -2 ft. MSL contour for the three study surveys (Figures 21A and 21B). Beach fill trends after six month (August 1996-May 1997) show that seaward movement of MHW at profile 45 is negligible, but during the next six months, the profile accretes seaward. This same pattern and magnitude occurs at profile 49 which is about the same distance south of the southern fill limit that profile 45 is north of the northern fill limit. For the subaerial beach, this indicates relatively equal dispersion of the fill alongshore equidistant from the fill limits.

Profiles 46 and 48 straddle the fill area, 1,000 and 2,000 ft. away, respectively. These profiles have similar patterns of MHW movement initially, advancing during the first six months but then significantly receding on profile 46 and remaining unchanged on profile 48. Profile 47, in the heart of the beach fill, shows the expected high rate of shoreline advance after the first six month, then a slight erosional trend over the second six months.

The -2 ft. MSL contour change is somewhat more variable. A significant seaward advance took place during the second six months for the northern four profiles and profile 49.



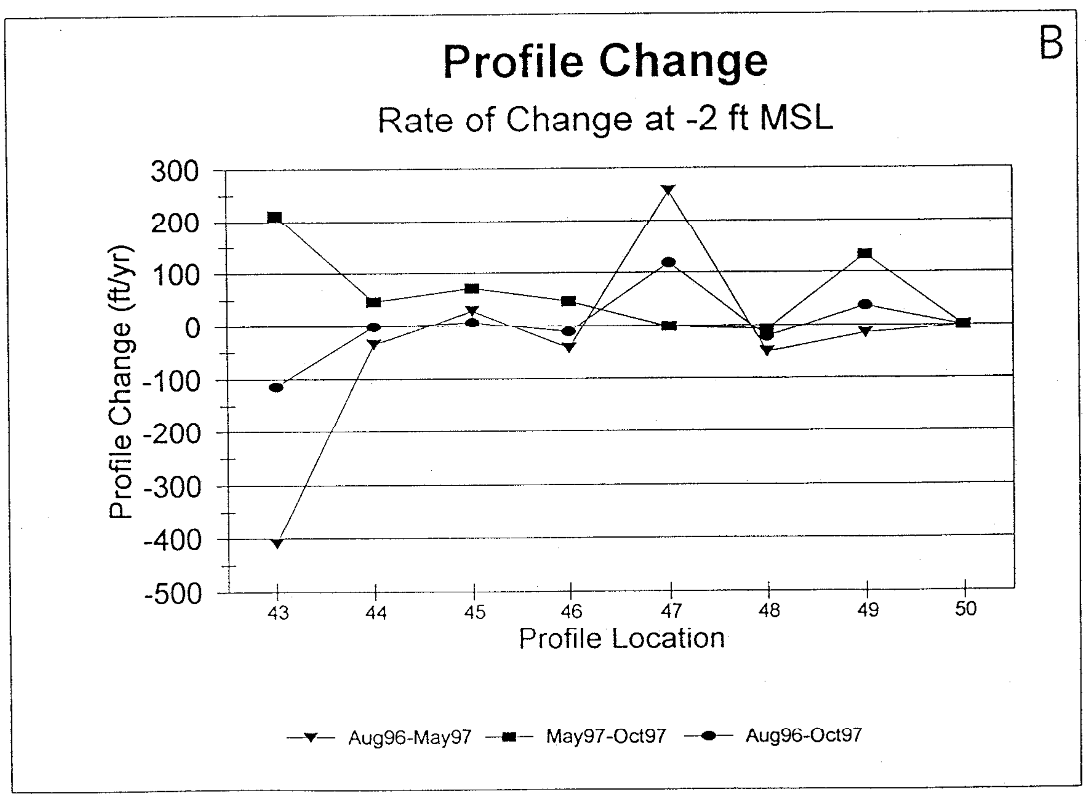


Figure 21. Profile change at A) MHW and B) 2 ft. below MSL.

This may reflect alongshore transport via the nearshore bar and swale zone which does not appear in the pre-fill survey. At about mid-fill, profile 47, a similar trend as MHW is seen but there is little movement of the -2 ft. MSL contour. It must be kept in mind that the land survey for the October 1997 data were performed prior to the October 15 to 19 northeaster.

Volumetric changes were calculated for the area of the profiles above MSL and below MSL. Patterns similar to changes in MHW are evident in volume change (cubic yards/linear ft., cy/ft) above MSL (Figure 22A). The subaerial beach at profile 47 shows the mass of sand placed on the beach during the project. Between August 1996 and May 1997, little volume change occurred above MSL north and south of the fill at profiles 44, 45, 48, 49, and 50. However, between May and October 1997, north and south of the fill was accreting (profiles 43, 44, 45, and 49) and little change occurred at profiles 46, 47, and 50. The large subaerial loss at profile 43 between August 1996 and May 1997 can be attributed to the dredging at Rudee Inlet.

Figure 22B shows the net volume change between pre-fill and one year after the fill below MSL. The same patterns of erosion and accretion are seen below MSL but to a much lesser extent volumetrically than the subaerial beach. Little change occurs at profile 50 over the year of this study.

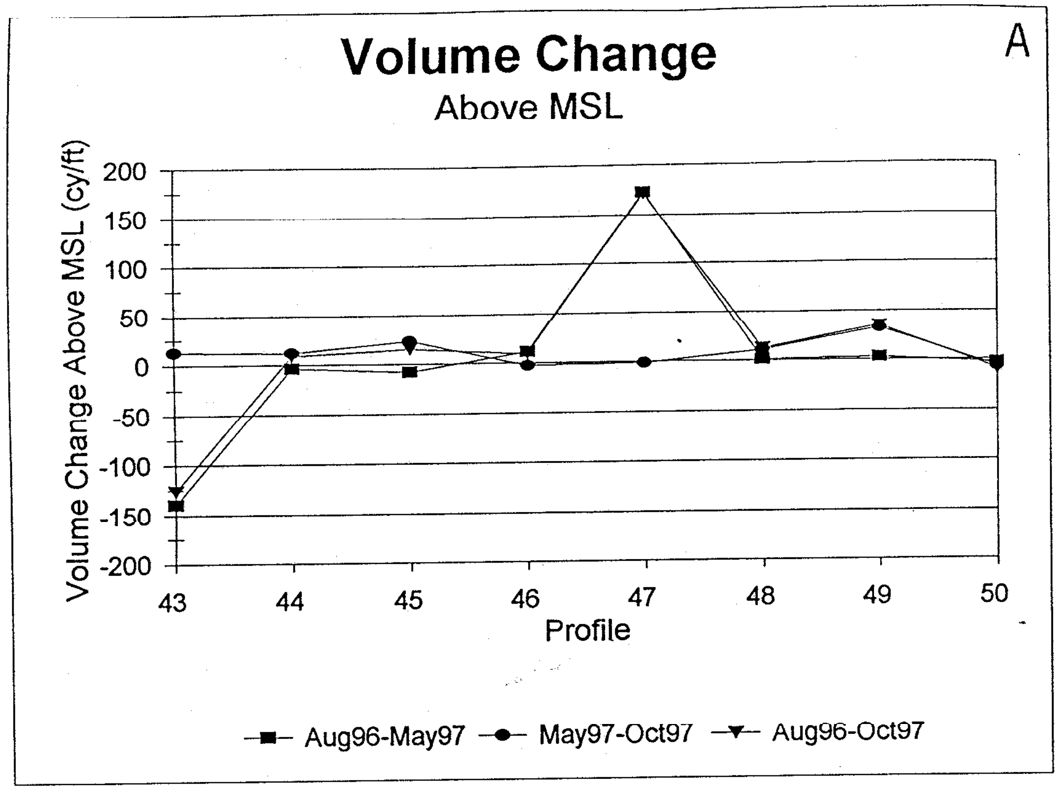
The spreading of the beach fill also was tracked with aerial imagery where MHW was taken off low-level, non-rectified aerial photos. The MHW plot, Figure 23, shows the northward and southward spreading of the beach mass. Erosional areas are seen along the front cusp of the beach fill feature showing the differential loss of the fill there.

Subaerial Beach and Nearshore Sediments

The subaerial beach and nearshore was sampled for sediment characteristics. Samples were taken at the Dune (crest), Base of Dune (BOD), Midberm, Berm, Midbeach, TOE of beach face and the -2 MSL contour (Figure 7). The offshore was characterized by sediments taken at "-6", "-12", "-18", and "-24" ft.. The beach at profile 47 was not sampled prior to the fill since it would be buried after the project. The complete sediment analyses are presented in Appendix A. For this discussion, the median grain size and sorting are plotted together for each sample location. Figures 24A and 24B depict the sediment parameters for the natural foredune crest. Data are missing because either there was no dune crest feature or the profile line began seaward of the dune crest. On average, the median grain size gets slightly coarser with time (Figure 24A) and stays well sorted (Figure 24B).

The average alongshore grain size of the base of dune (BOD) becomes slightly finer from August 1996 to May 1997 but gets coarser again in October 1997 (Figure 25A). Profile 47, the beach fill, is slightly coarser than adjacent reaches. Sorting goes from well-sorted (August 1996) toward moderately well-sorted by May 1997 and October 1997 (Figure 25B). Both dune crest and BOD were primarily influenced by aeolian processes over the study period. The occurrence of high water and wave runup were negligible.

The midberm region's average alongshore grain size goes from a fine to medium sand to a medium sand (Figure 26A). Post-fill samples coarsen slightly to the north of the fill and fine to



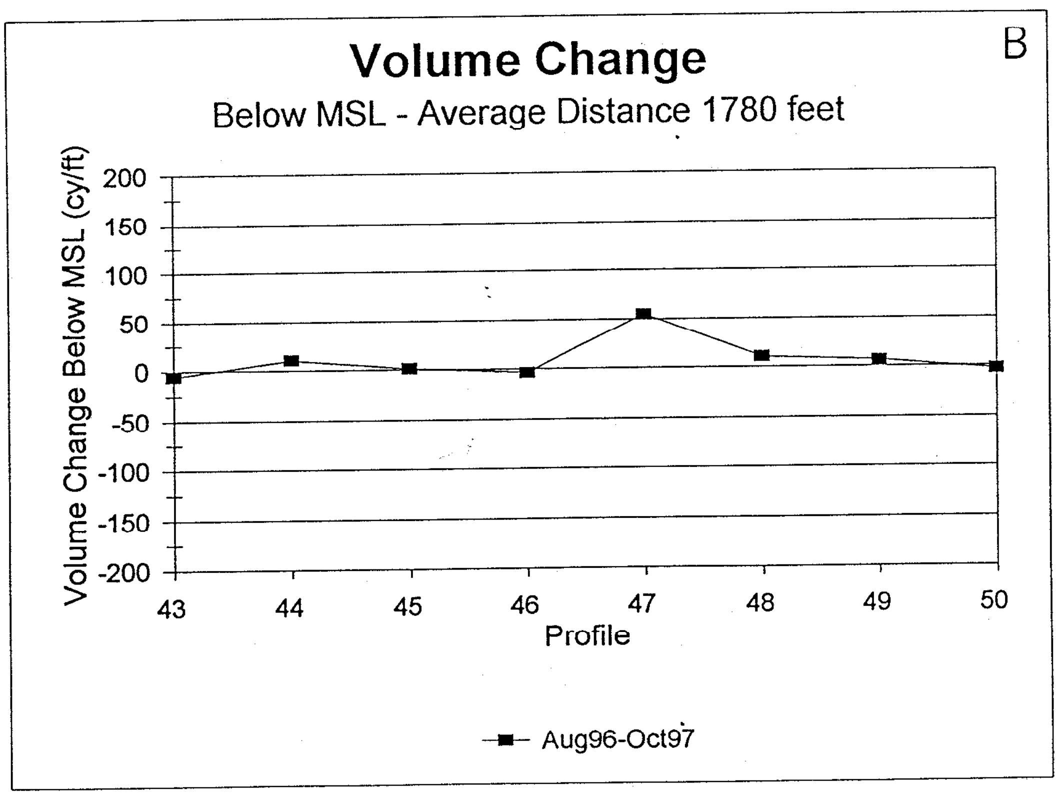


Figure 22. Volume change A) above MSL and B) below MSL to an average distance of 1,780 ft. from the benchmark.

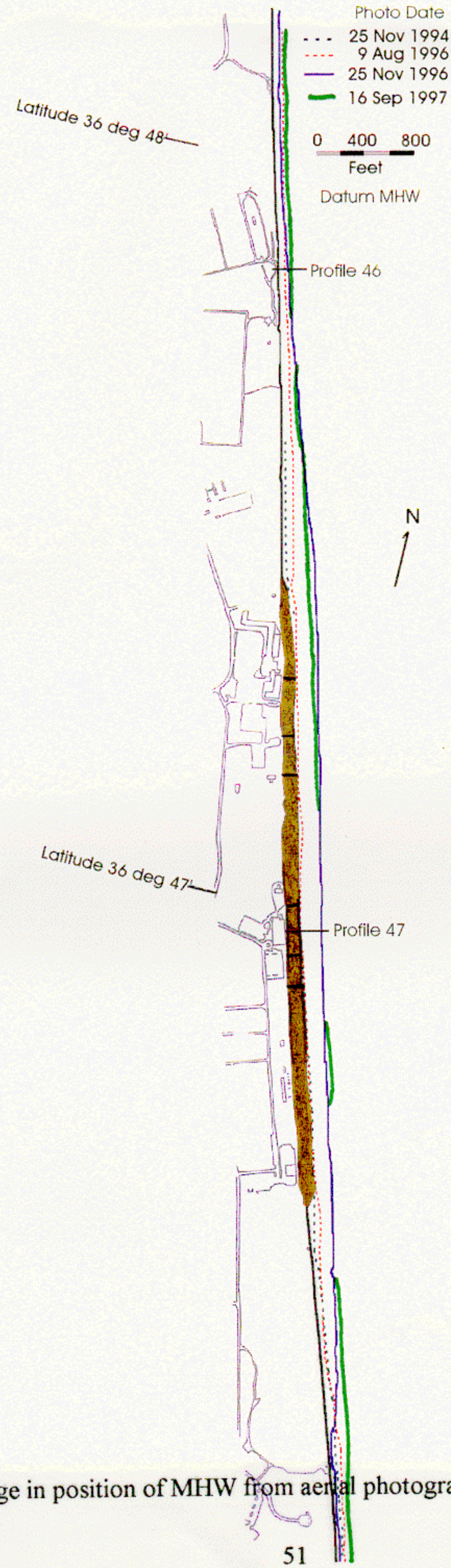
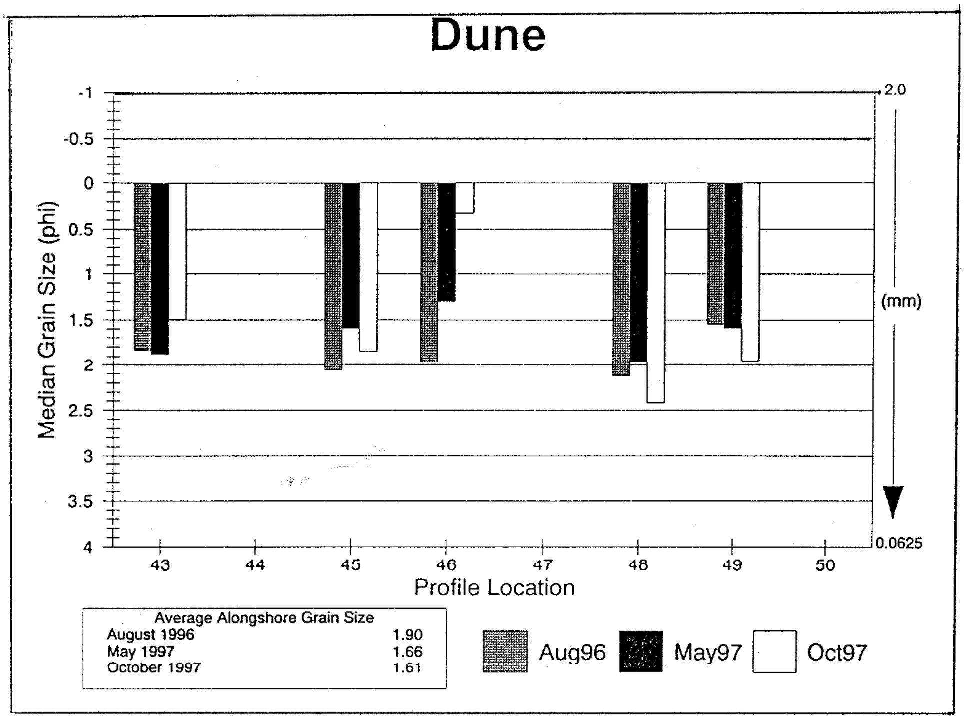
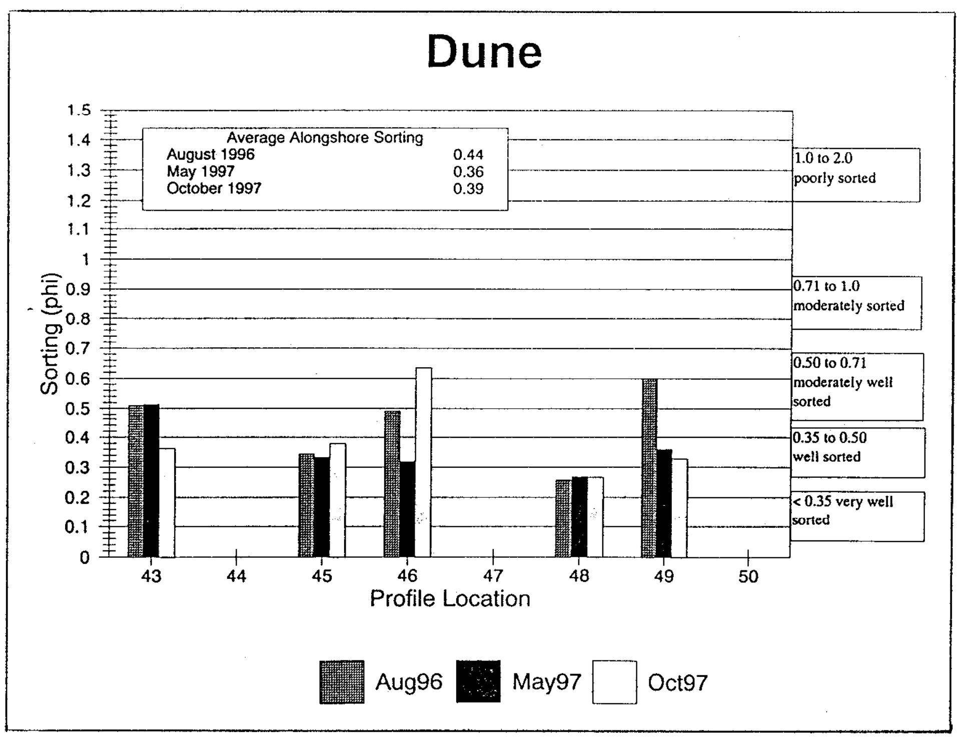


Figure 23. Change in position of MHW from aerial photography.

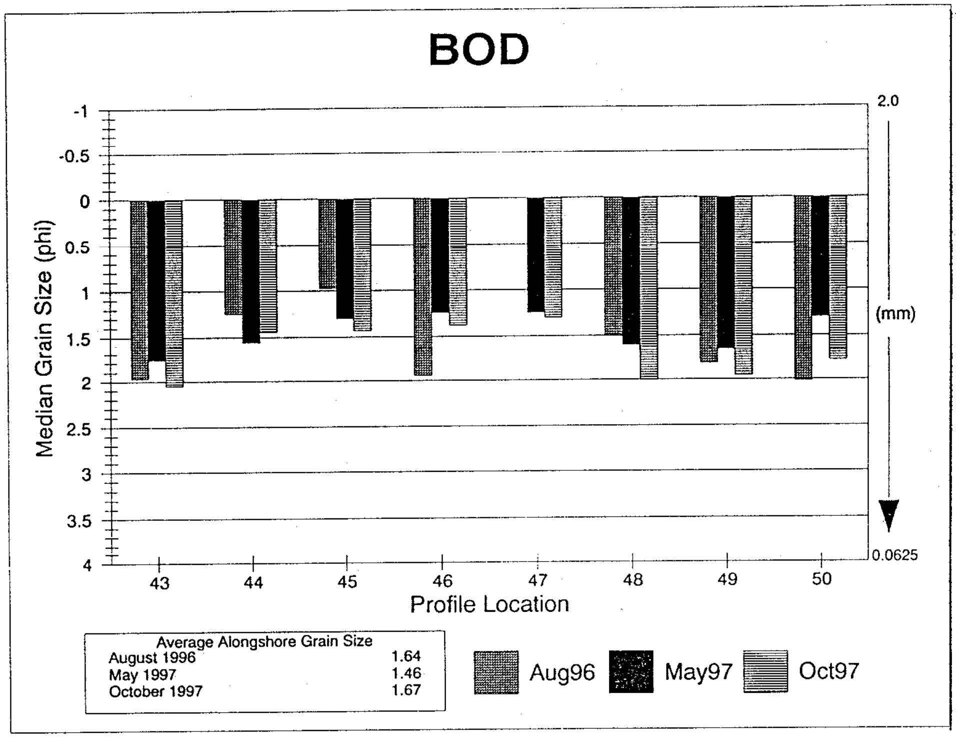


A

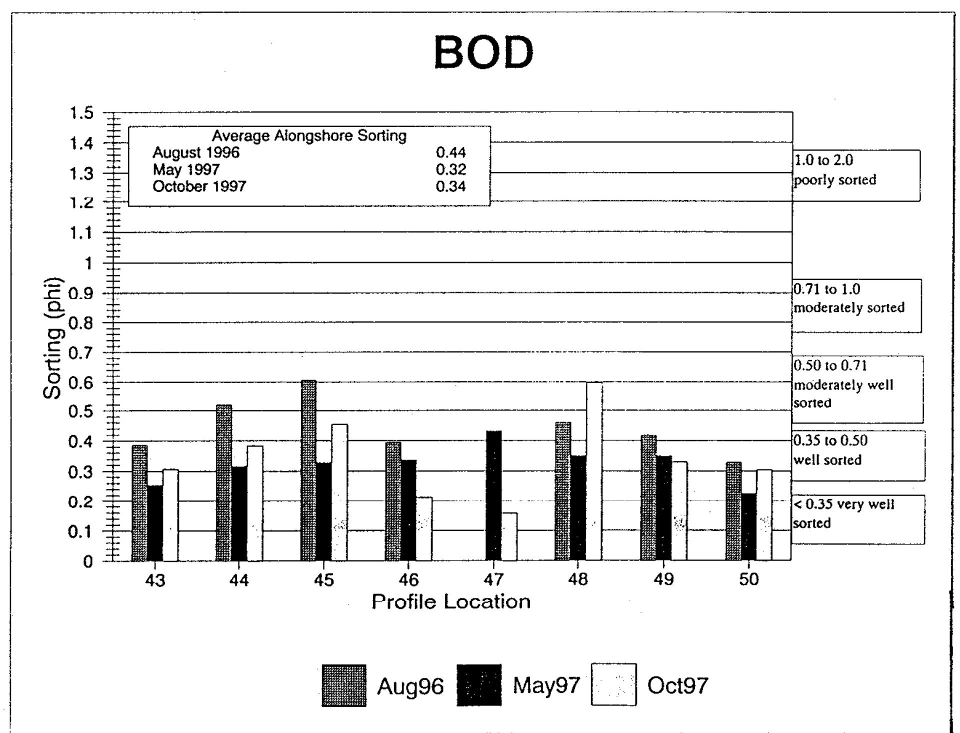


B

Figure 24. Dune A) median grain size and B) sorting.

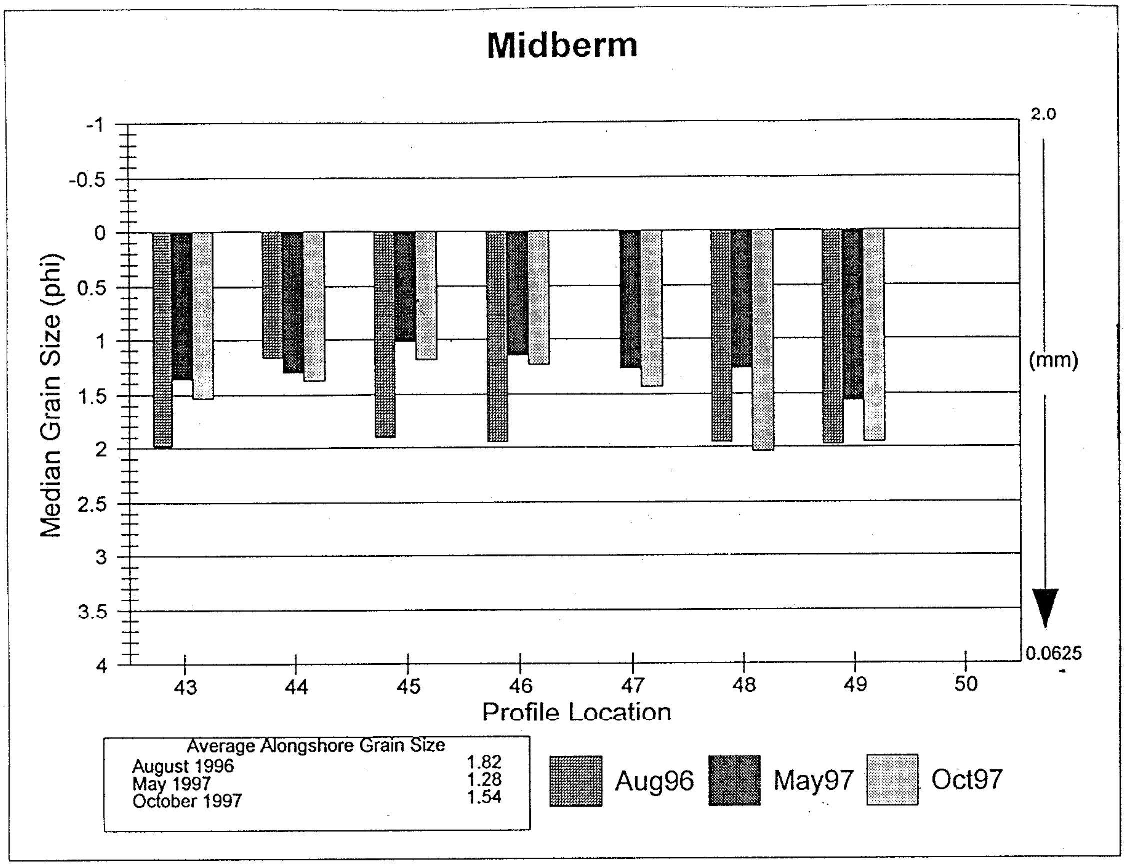


A

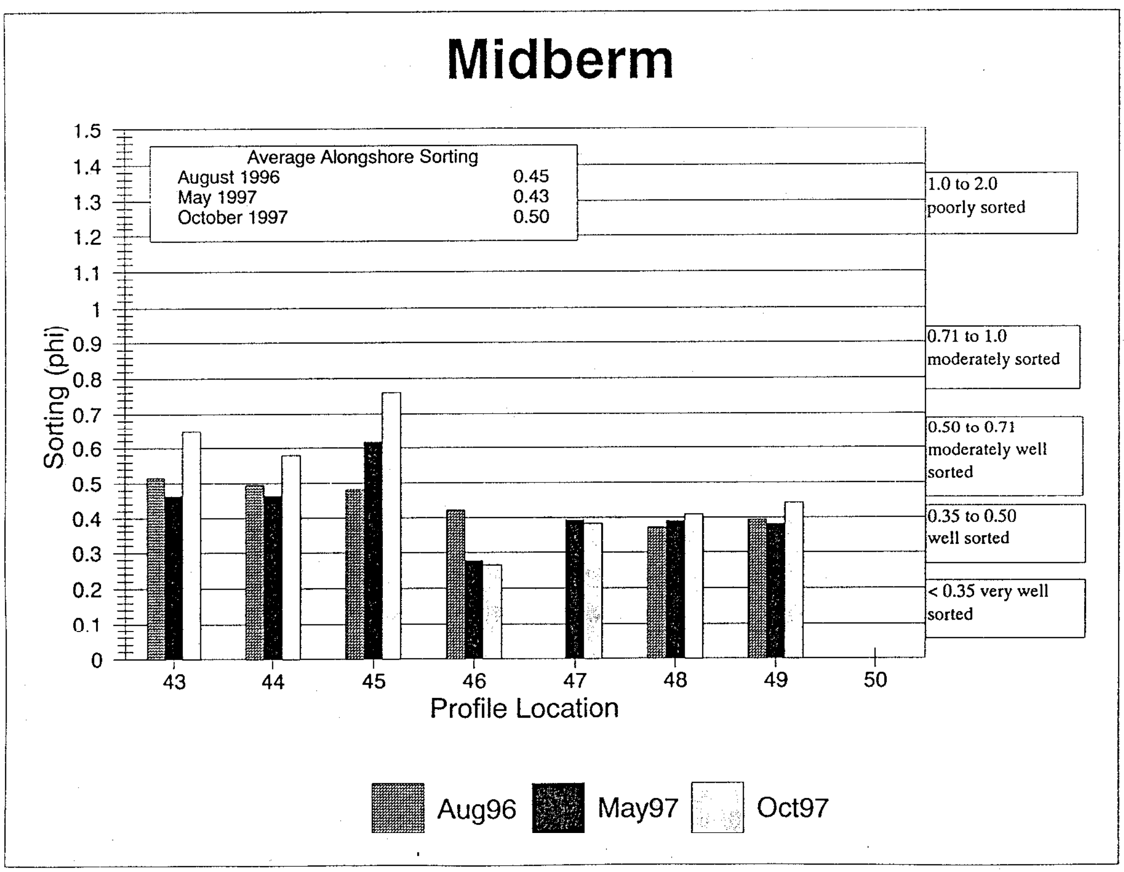


B

Figure 25. Base of dune A) median grain size and B) sorting.



A



B

Figure 26. Midberm A) median grain size and B) sorting.

the south. Sorting patterns, in general, show better sorting from profile 46 south (Figure 26B). The overall average pushes the study total to a moderately well sorted status over time.

The berm feature shows a significant increase in the average alongshore grain size from August 1996 to May 1997 with a slight decrease by October 1997 (Figure 27A). With the exception of profile 44 and 46, this trend occurs at each profile where there are 3 samples for three dates. Profiles 48 and 49 show a fining median grain size in October 1997 about equal to the August 1996 sample. The average alongshore sorting is generally well-sorted (Figure 27B).

The average alongshore grain size variability for the midbeach zone is significant (Figure 28A). There is an average increase of about one phi size from August 1996 to May 1997 and a one phi size decrease from May 1997 to Oct97. This may be a seasonal trend in the active beach zone. Between August 1996 and May 1997, the midbeach zone becomes coarser north of the fill and at profile 50. All profiles become finer from May 1997 to October 1997. The average sorting is within the moderately well sorted range (Figure 28B). The May 1997 and October 1997 sorting is better or toward the well sorted range for profiles 46 to 50 relative to the northern profiles (i.e. 43,44 and 45).

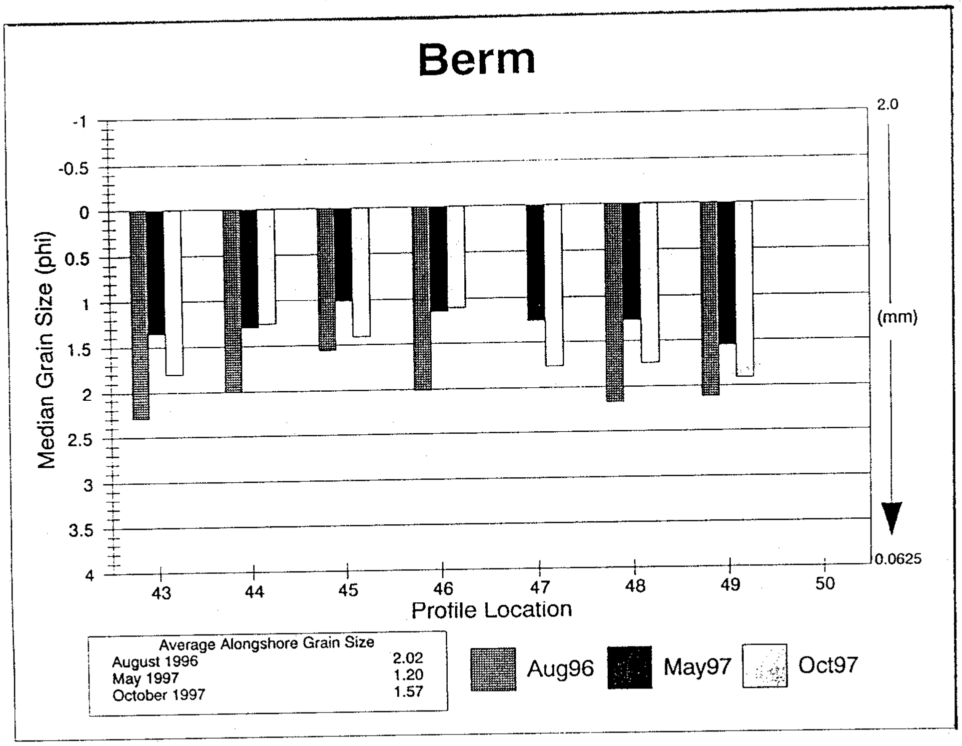
The beach TOE or step is quite variable for median grain both alongshore and through time (Figures 29A and 29B). The average alongshore grain size increases by one phi size from August 1996 to May 1997 and then becomes finer by an average of one and one-half phi size from May 1997 to October 1997. This variability also may be explained as seasonal trends. The TOE sediments become generally better sorted through time (Figure 29B).

The “-2" average alongshore median grain size is generally finer than the subaerial beach sediments with a coarsening trend from August 1996 to May 1997 and a fining trend from May 1997 to October 1997 (Figure 30A). Once again this appears seasonal. Also, the May 1997 data was obtained near the inner bar crest. The general trend for sorting is to become better sorted with time (Figure 30B).

The “-6" sediments become slightly coarser with time (Figure 31A), and there is little significant change in sediment sorting (Figure 31B). The “-12" sediments trend slightly finer with time and become slightly better sorted (Figures 32A and 32B).

The “-18" sediment samples get slightly coarser between August 1996 and May 1997. Between May and October 1997, however, the average grain size has returned to what it was in August 1996, indicating a seasonal change in sediment size (Figure 33A). At this depth and distance offshore, the sand size fraction is very fine sand. The sorting differs from the median grain size in that it becomes better sorted between August 1996 and May 1997, but between May and October 1997, the sorting value does not change (Figure 33B). The “-24" sediment trends are slightly coarser then finer with time (Figure 34A). The sorting is generally very well-sorted becoming slightly better sorted over the study period (Figure 34B). At individual profiles, the median grain size stays relatively the same, but sorting values vary at profiles 48 and 50.

The overall sample can be characterized by the percentage of gravel, sand, silt, and clay in the sample. Generally, the samples contained mostly sand. Overall, the samples taken in the



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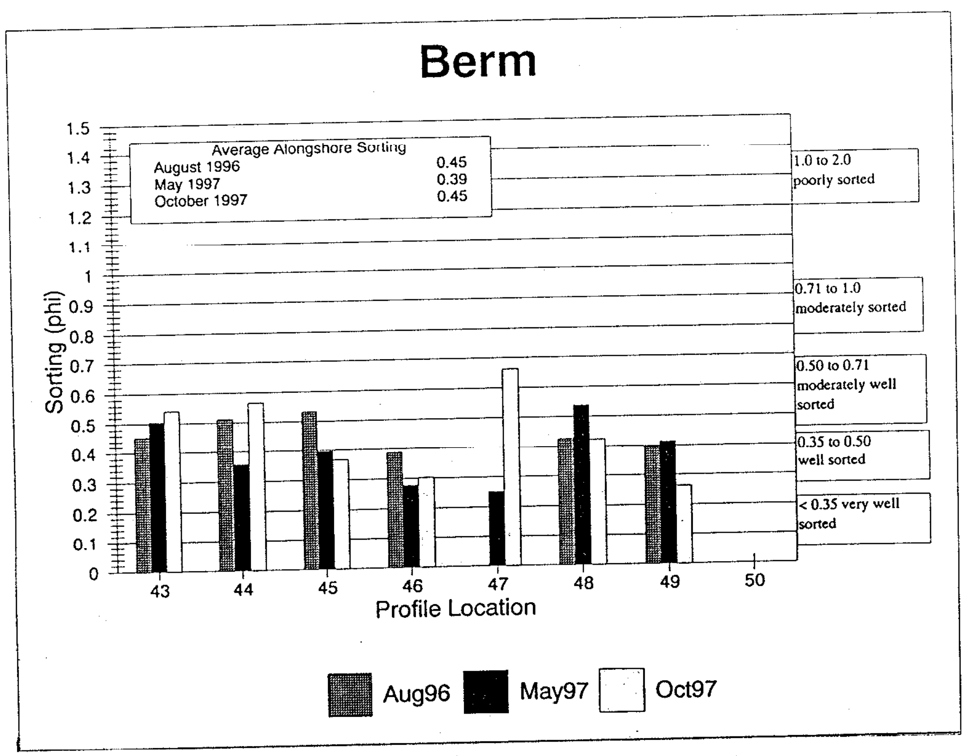
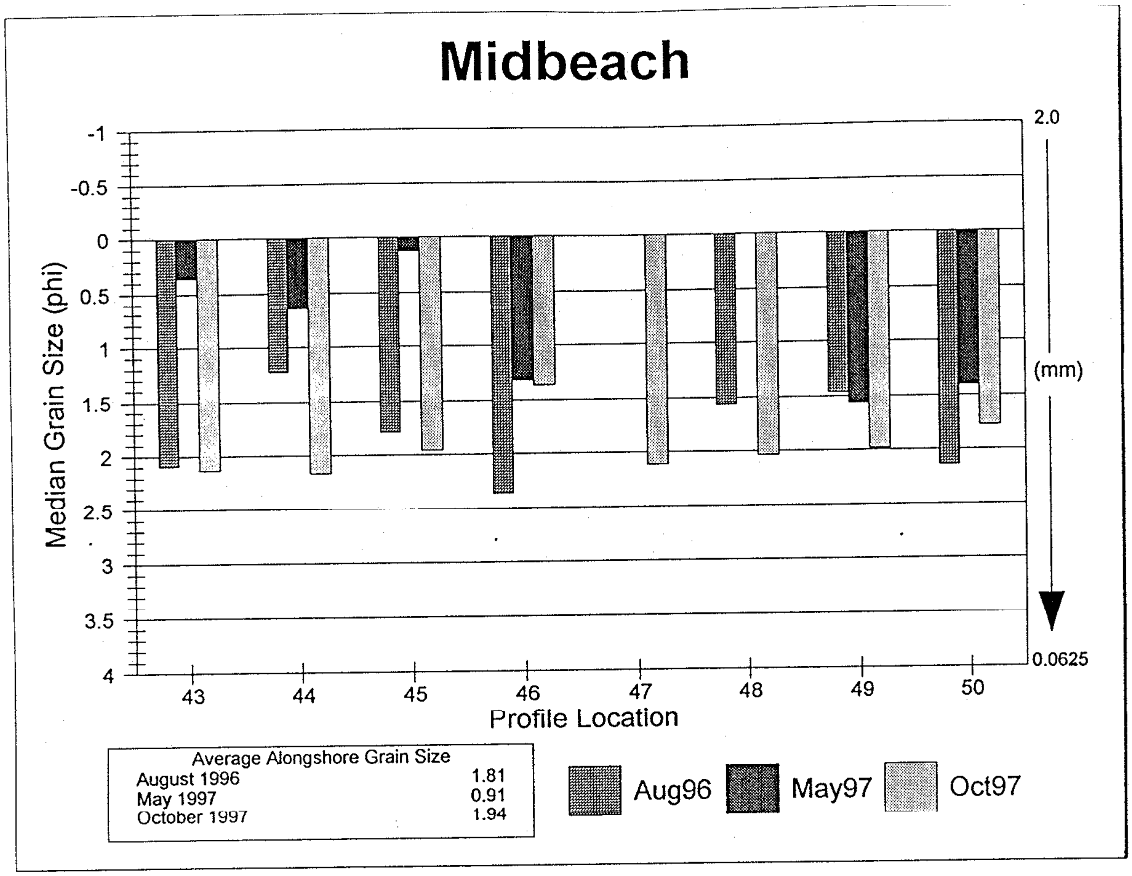
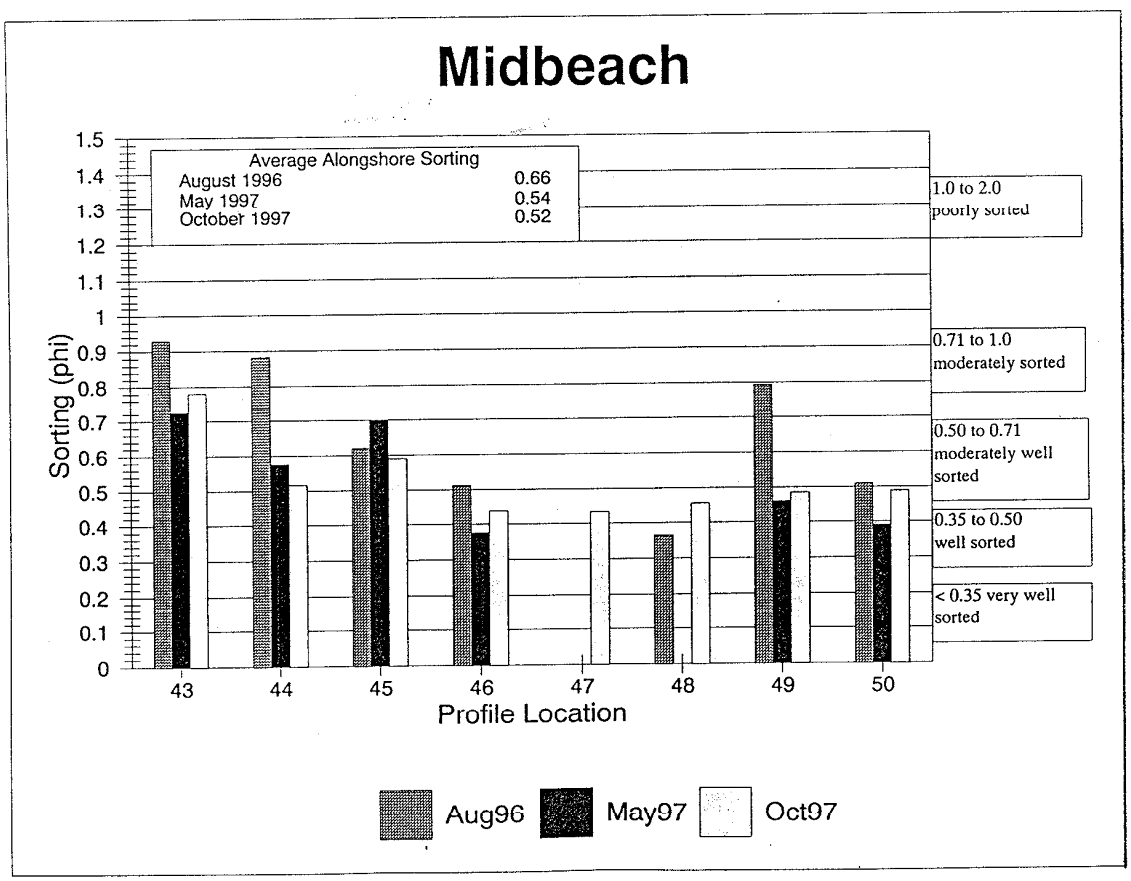


B

Figure 27. Berm A) median grain size and B) sorting.

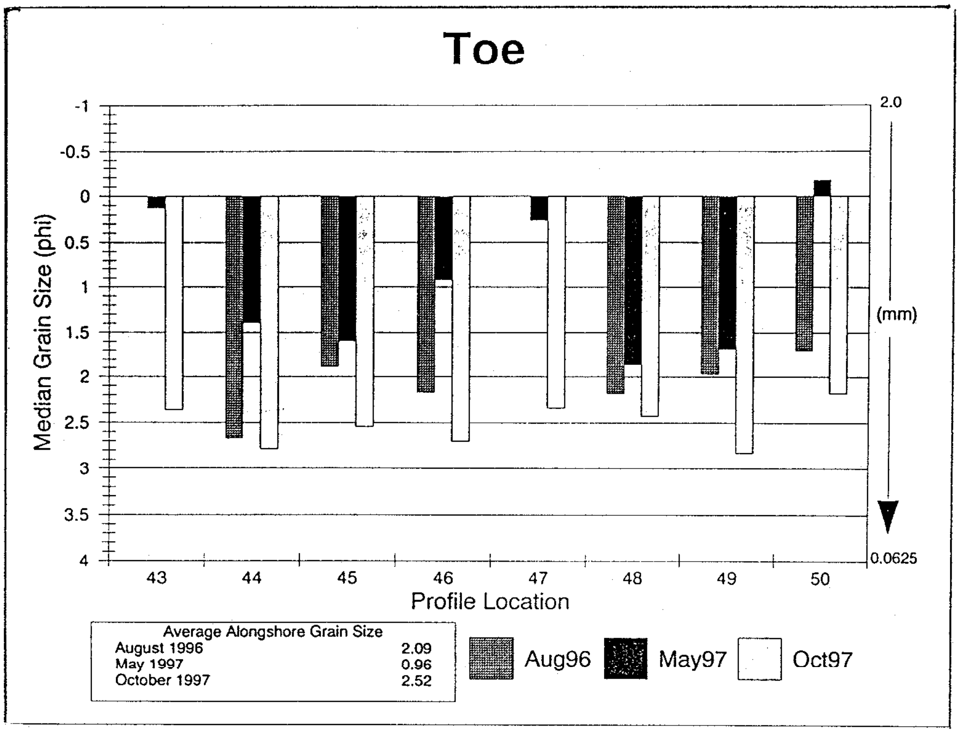


A



B

Figure 28. Midbeach A) median grain size and B) sorting.



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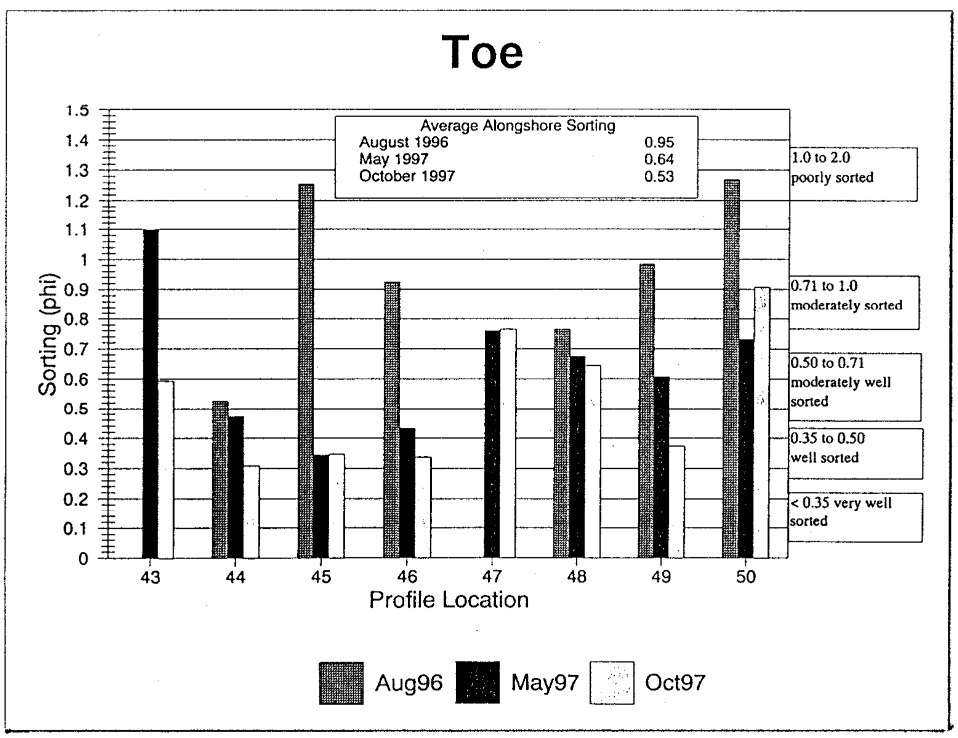
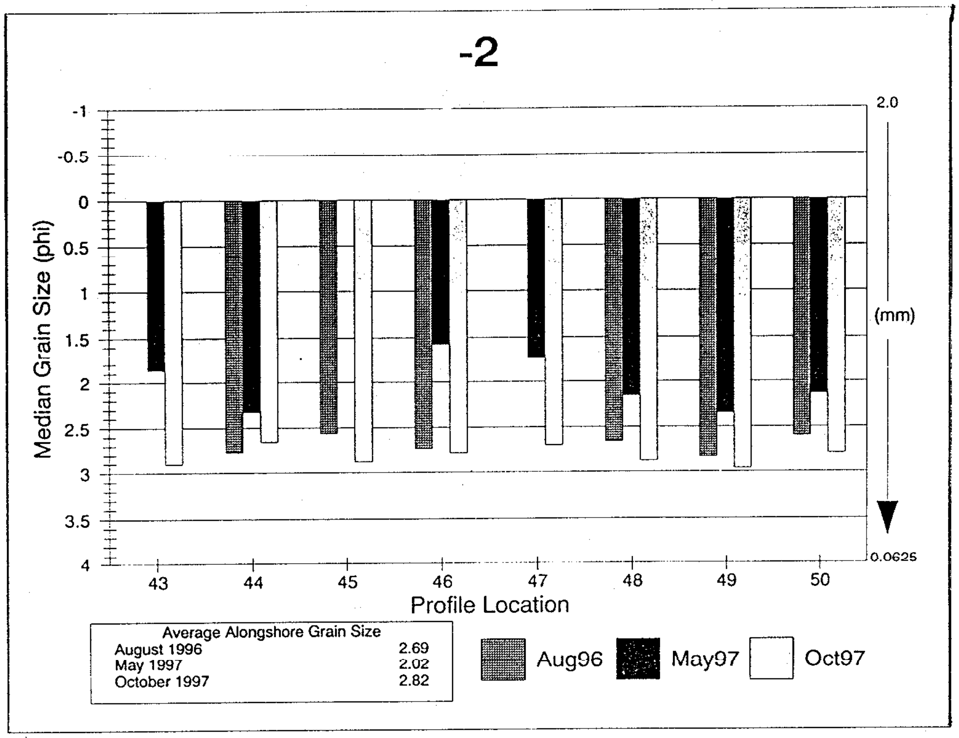


B

Figure 29. TOE A) median grain size and B) sorting.



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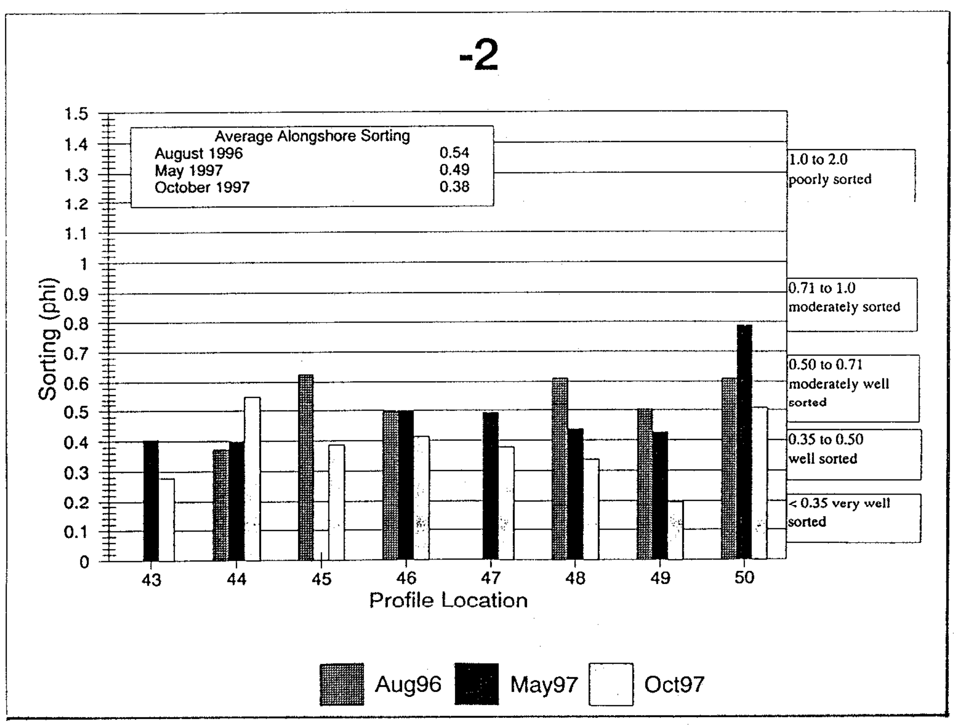


B

Figure 30. "-2" A) median grain size and B) sorting.

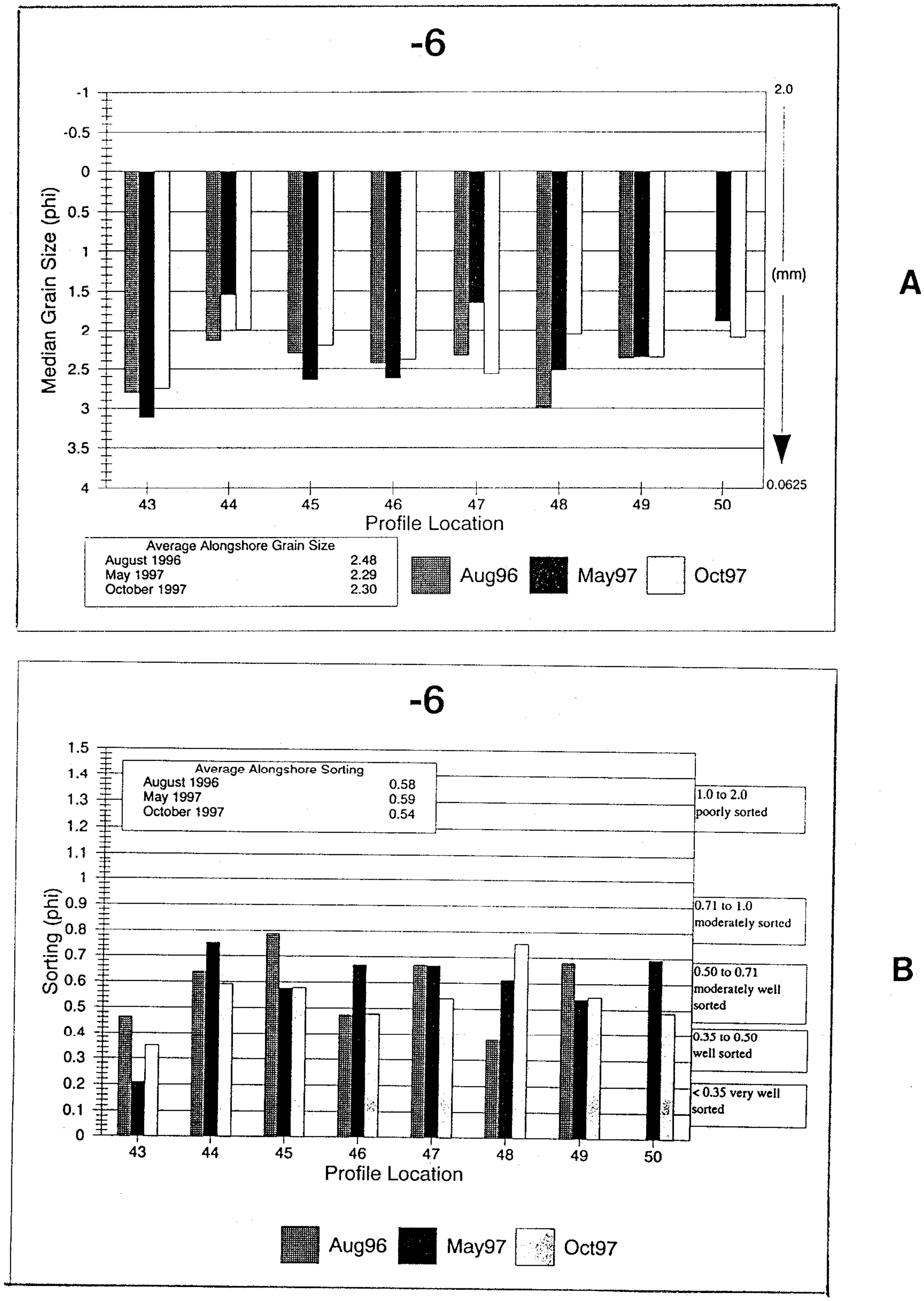
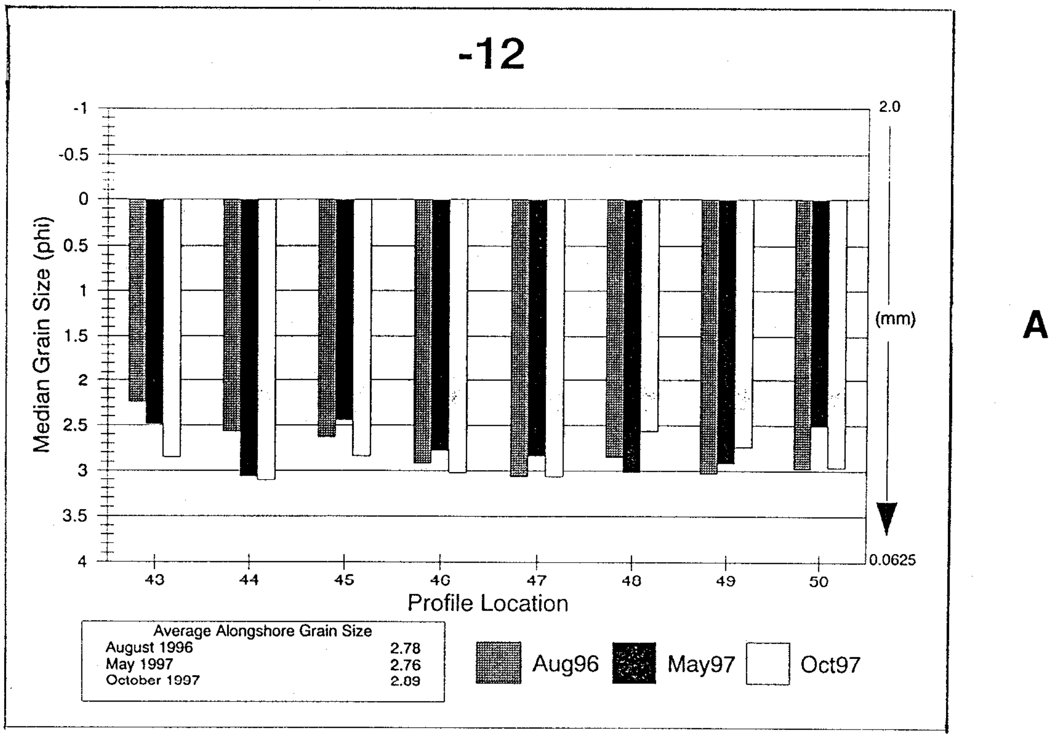


Figure 31. "-6" A) median grain size and B) sorting.



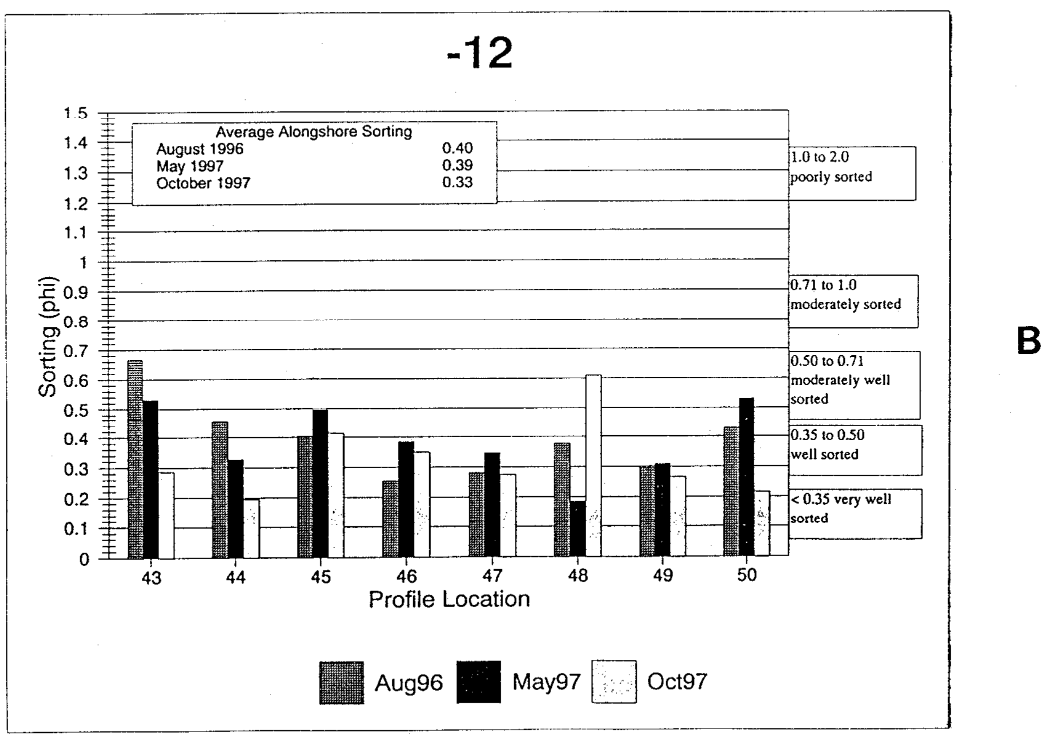
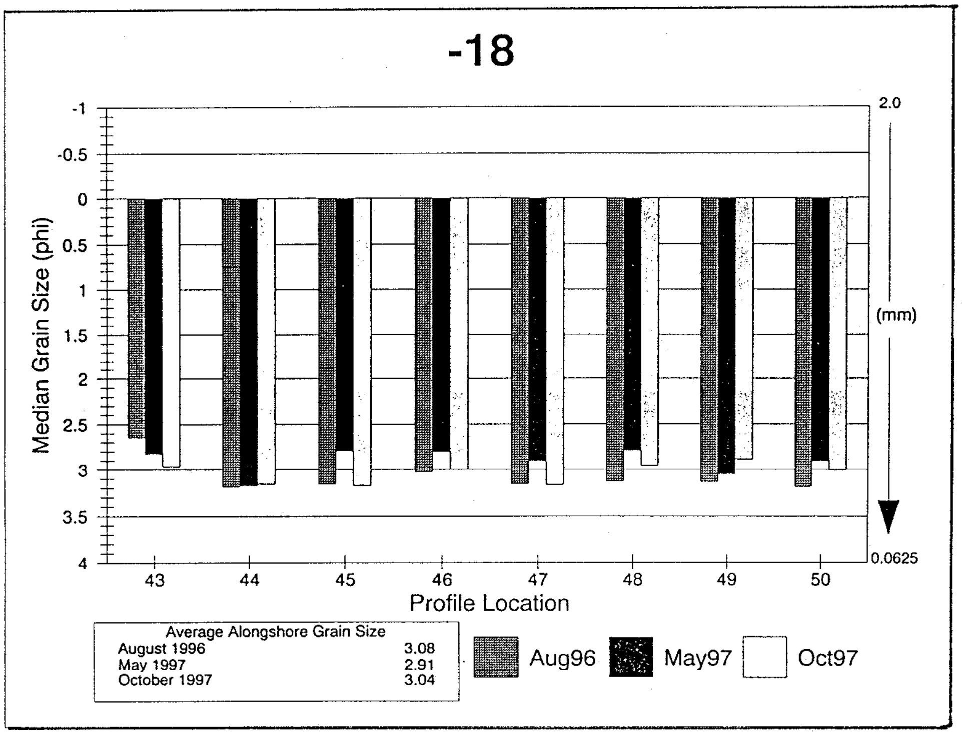
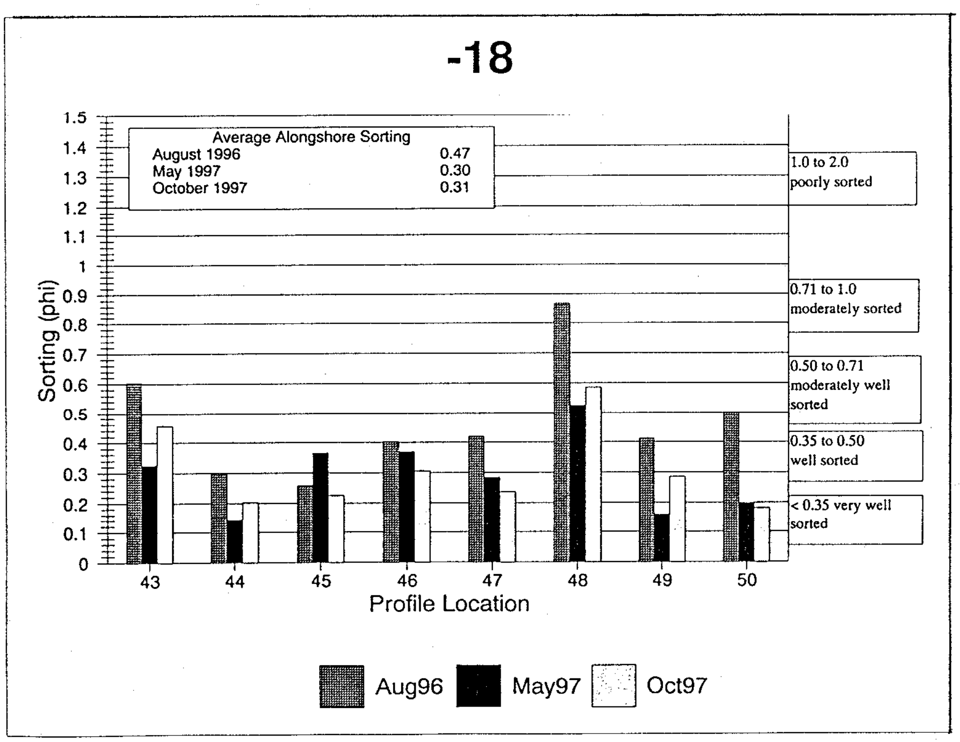


Figure 32. "-12" A) median grain size and B) sorting.

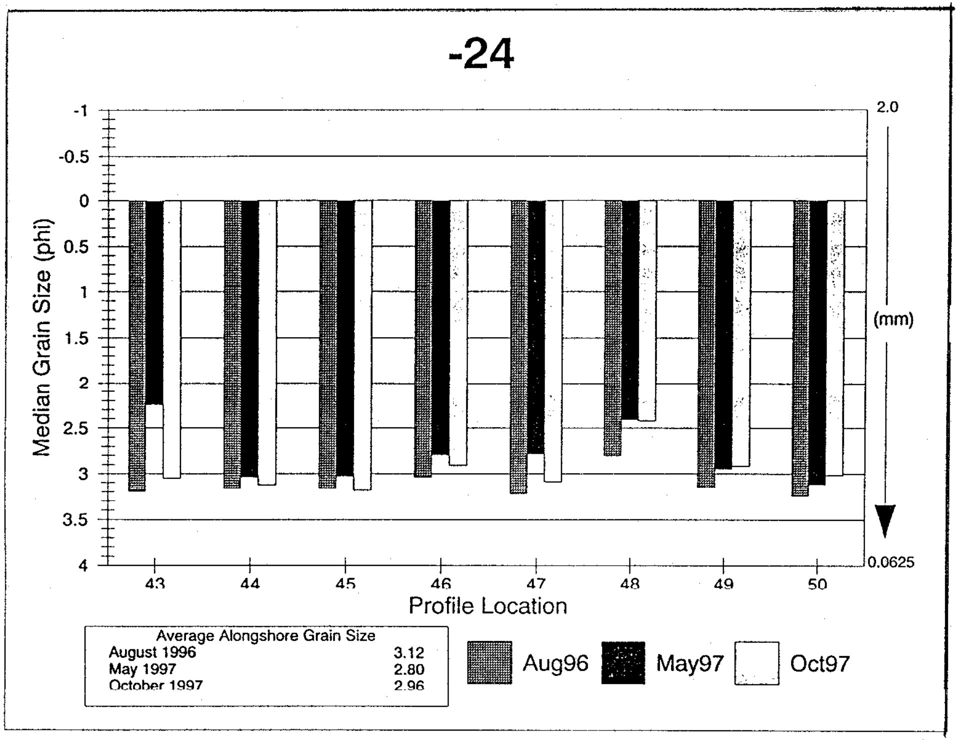


A

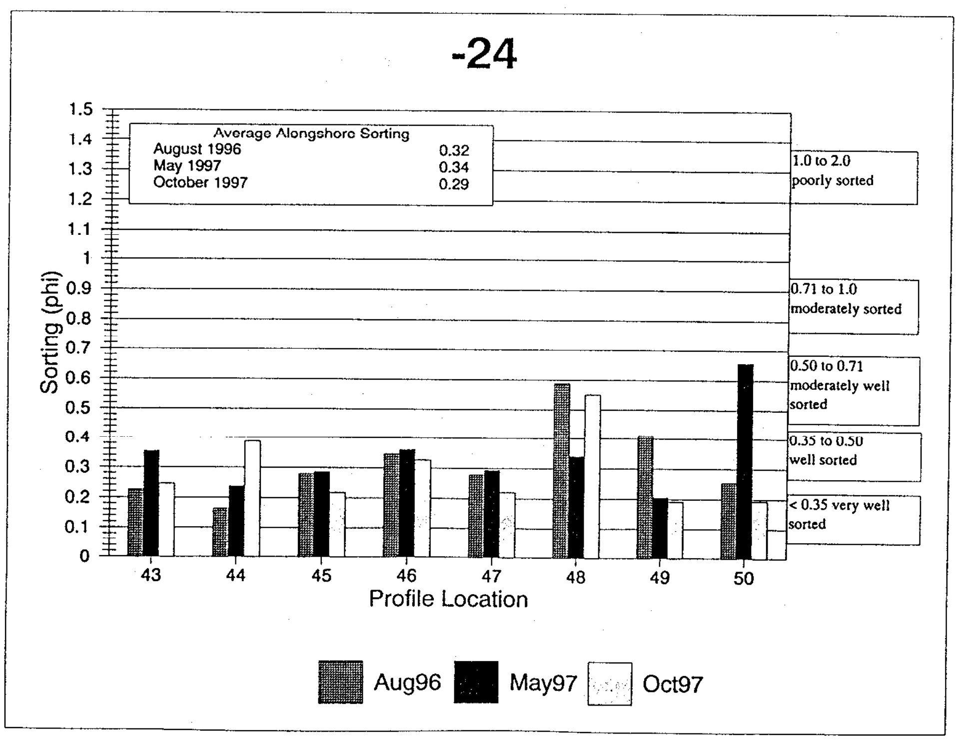


B

Figure 33. "-18" A) median grain size and B) sorting.



A



B

Figure 34. "-24" A) median grain size and B) sorting.

course of this study contained little silt and clay, so they are discussed collectively as mud. The samples taken in August 1996 revealed very little gravel, and most of the mud was located in the offshore samples. The mud content was highest at the “-24" sample; profile 44, sample “-24" contained 51% mud, and profile 50, sample “-24" had 14% mud. In May 1997, the highest mud content generally was in the offshore samples with profile 43, sample “-24" having the highest content at 20%. The samples taken in May 1997 had about the same gravel content as in August 1996. The samples taken in October 1997 contained much less gravel and mud than in May 1997. In October, none of the samples had over 3% mud in the sample. The TOE at profile 47 had 24% gravel, and the TOE at profile 45 had 9% gravel. Other than these samples, no others had more than5% gravel in the sample.

Discussion

Several trends are evident in the results of the one year monitoring study of the DNBNP. The movement of the beach fill material has taken place both alongshore and offshore. The subaerial beach change of the position of MHW and the -2 ft. contour through time (Figures 20A and 20B) are qualified in Table 5. Generally, there is significant accretion associated with the beach fill mass from August 1996 to May 1997. Then erosion of the seaward side of the main fill (profile 47) occurs as the material spreads laterally.

Table 5

	MHW	Change Figure 20A	-2	Change Figure 20B
Profile	Aug96-May97	May97-Oct97	Aug96-May97	May97-Oct97
43	erosion	no change	erosion	accretion
44	small accretion	small accretion	erosion	accretion
45	no change	accretion	accretion	accretion
46	accretion	erosion	erosion	accretion
47	accretion	erosion	accretion	no change
48	accretion	no change	erosion	no change
49	no change	accretion	erosion	accretion
50	no change	erosion	no change	no change

Summary of relative profile change at the position of MHW and the -2 ft. contour as shown in Figures 20A and 20B.

Volume changes (Table 6) above MSL show gains in the subaerial beach either side of the fill. Volumetrically there appears to be a net gain of subaerial beach to the south. This is also evident more dramatically of the offshore gains southward especially profile 48. These trends indicate a net southward movement of the beach fill mass after one year. This trend was occurring before the October 15 to 19, 1997 northeasters for the subaerial beach. That same storm period is most likely responsible for the offshore trend associated with the southward movement. Wind data obtained at Norfolk International Airport from that event reflects primarily a north and northeast wind field with consequent southward driving wave conditions. This storm had the most impact to the project since placement in the fall of 1996.

Table 6

	Volume Change Above MSL Figure 21A		Volume Change Below MSL Figure 21B
Profile	Aug96-May97	May97-Oct97	Aug96-Oct97
43	loss	gain	small loss
44	no change	gain	small gain
45	loss	gain	no change
46	gain	no change	small loss
47	gain	no change	gain
48	no change	gain	gain
49	no change	gain	small gain
50	no change	no change	small loss

Summary of relative volume changes above and below MSL as shown in Figures 21A and 21B.

The one year (Aug96-Oct97) rate of change for MHW, obtained during the course of this study, is compared against historic trend and trends in City data (Figure 35). Profile 46 appears as an anomaly considering the large mass of sand placed only 1,000 ft. to the south. The net change over one year is about zero after an initial loss of about 40 ft. from August 1996 to May 1997. This may be attributable to wave refraction across the beach fill mass causing a localized wave energy concentration or a "hot spot" with sediment loss relative to adjacent shorelines. With time and the occurrence of storms, the beach planform will move toward a dynamic equilibrium in the longshore directions.

Equilibrium of the October 1997 steep, nourished beach face profile also will take place. This offshore shifting of fill sand has occurred as evidenced by the large inner bar features on profile 47. From historic City survey data, the natural inner bar is a more subtle feature. With the advent of the DNBNP, more distinct inner bars may develop due to the increased sand volume within the reach. The large bar and nearshore increase in sediment volume on profile 48 are evidence of the net offshore and southward movement of the beach fill beyond its original limits; these features are not seen on adjacent profiles north of the project. The offshore impacts of beach fill movement may extend beyond the depths of "closure" (approximately 30 ft. below MSL), at least initially.

Sediment trends for the subaerial beach (BOD to -2 ft) are seasonal changes with coarser sands occurring after the winter season (May 1997) and a return to finer grained material after the

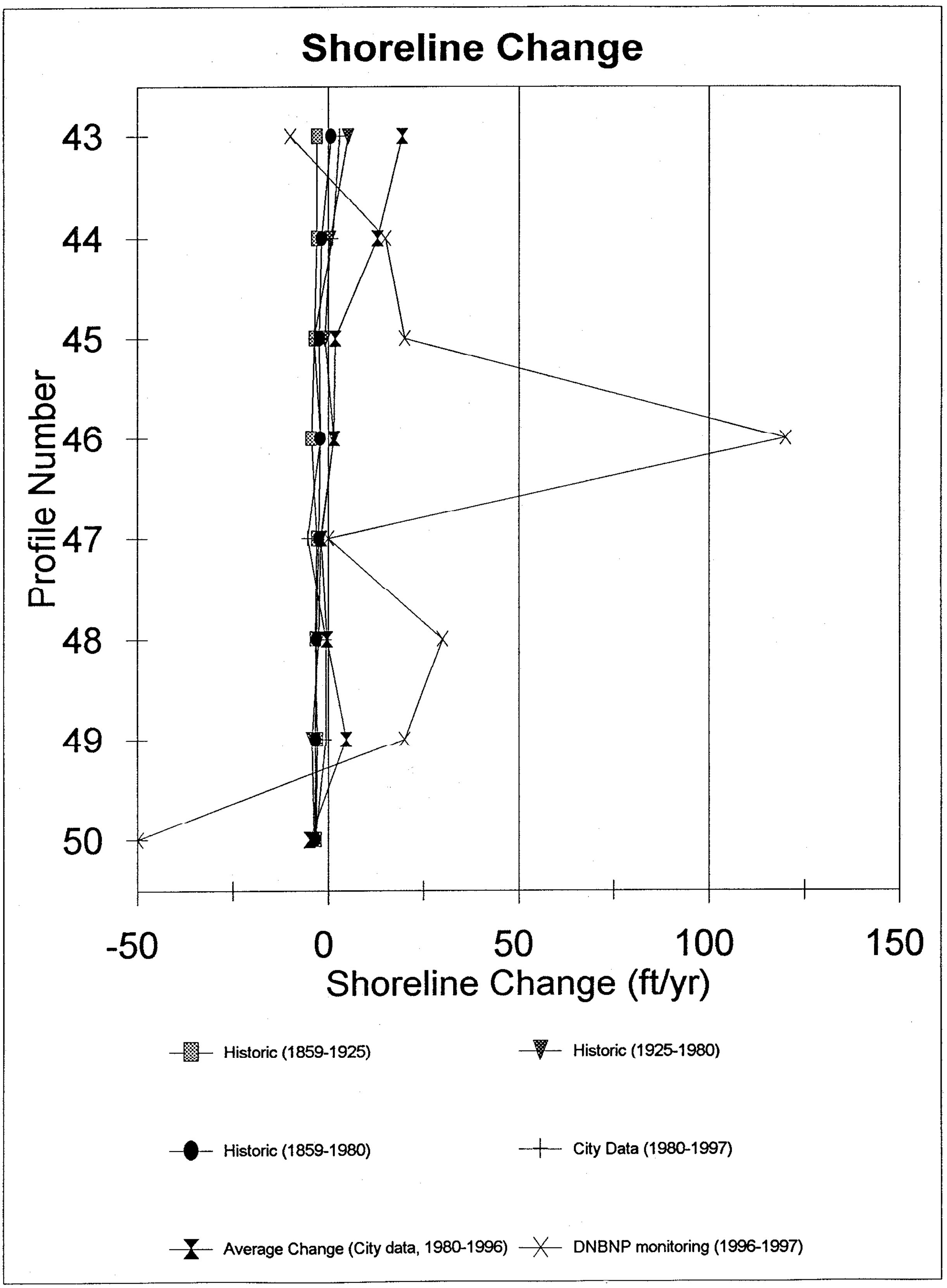


Figure 35. Rate of shoreline change using historical data, City survey data, and data obtained during the one year monitoring of DNBNP.

summer season (October 97). Table 7 qualifies this trend. The only two profile locations to get coarser with time are the Dune crest and the -24 ft.locations, the profile end points that are impacted separately by winds and waves respectively. Sorting generally gets better with time for the whole sediment suite except for the berm and midberm.

Table 7

	Median	Grain Size	Sorting	
Sample	Aug96-May97	May97-Oct97	Aug96-May97	May97-Oct97
Dune	coarser	no change	better sorted	little change
BOD	coarser	finer	better sorted	little change
Midberm	coarser	finer	no change	less sorted
Berm	coarser	finer	better sorted	less sorted
Midbeach	coarser	finer	better sorted	better sorted
TOE	coarser	finer	better sorted	better sorted
“-2"	coarser	finer	better sorted	better sorted
“-6"	coarser	no change	little change	little change
“-12"	little change	finer	better sorted	better sorted
“-18"	coarser	finer	better sorted	no change
“-24"	coarser	finer	little change	better sorted

Summary of the relative average alongshore sediment statistics of the study site as shown in Figures 23-33.

VII. Conclusion

On a regional scale, the DNBNP lies within an area of historic shoreline recession. False Cape and Cape Henry and their associated shoal systems act as headlands that modify the wave energies impacting the shoreline. Between the two headlands a long, curvilinear embayment has formed as the shoreline has adjusted to the waves impacting the shore. The wave energy impacting the shore generally comes from the southeast with northeast storms occurring during the winter. The waves are modified by a complex offshore bathymetry that tends to concentrate wave energy in Sandbridge just south of the study area. This system is difficult to characterize since it is so variable. Data collected indicate large seasonal changes in morphology and sedimentology as well as variable rates of change through time.

In addition to natural trends, man has also impacted this shore reach. The only interruption along the shoreline is Rudee Inlet. The weir and jetty system at Rudee Inlet has influenced the shore morphology through time by acting as a littoral barrier and allowing sediments to accrete southward with only intermittent losses due to annual dredging. Since 1988, bulkheads have been built and the beach bulldozed all along Sandbridge as erosion threatened structures. Although these actions have led to a loss of the subaerial beach, the bulkheads have stabilized the rates of change in the area.

Beach nourishment as a means of shore protection has long been suggested as the best means to abate erosion along this shore reach. The DNBNP has added over 1,000,000 cubic yards of good quality beach sand to the littoral system. Whether the fill will be effective as shore protection at Dam Neck for 12 years, the Navy's projected fill life expectancy before renourishment is required, is yet to be seen. However, the impacts to the beach and nearshore region of adjacent shores will be positive in the sense that increased profile dimensions not only will abate shore recession but the added critical mass should reduce the historic losses for some time. The proposed addition of another 1,000,000 cubic yards to the south along Sandbridge in the spring of 1998 will complement the DNBNP.

In general, the DNBNP has spread both alongshore and cross-shore as material is eroded from the center of the fill. The mechanisms for transport indicate that, in addition to being moved subaerially, as seen with the creation of a high water berm, sediment also may be moving to the north in the nearshore region through the bar and trough system. The direction of sediment movement relates to the predominant wave direction. The net northward transport rate indicates that more sand moves north than south over time, but the initial net subaerial movement of the fill is to the south. Increased dredging may be necessary at Rudee Inlet as the fill moves north since more sand is available for transport at least for a few years.

Acknowledgments

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Appendix A

Results of Sediment Analysis

Profile Number
Location of Sample
Distance from Benchmark in ft. for Beach Samples
Latitude of Offshore Samples, Minutes Shown in Column
Longitude of Offshore Samples, Minutes Shown in Column

Entire Sample Analyses
Percent of Gravel in Sample
Percent of Sand in Sample
Percent of Silt in Sample
Percent of Clay in Sample
Percent of Mud (%Silt+%Clay) in Sample

Measures of the Sand Portion of the Sample
Moment Method of Analysis (M1, M2, M3, M4)
Graphic Mean (Mn)
Graphic Median (Md)
Sorting or Inclusive Graphic Standard Deviation
Inclusive Graphic Skewness
Graphic Kurtosis

1 aug 1996																		
Profile	Location	Dist (ft)	Latitude	Longitude	%grvl	%sand	%silt	%clay	%mud	M1	M2	M3	M4	Mn	Md	Sorting	Skewness	Kurtosis
			36 deg	75 deg										(Phi)	(Phi)	(Phi)		
			minutes	minutes														
43	Dune Crest	30			0.0	100.0	0.0	0.0	0.0	1.7659	0.5294	-0.4733	3.5667	1.7771	1.8242	0.5117	-0.1471	0.48
	BOD	43			0.0	100.0	0.0	0.0	0.0	1.946	0.4192	-0.7755	9.2604	1.9442	1.9625	0.3856	-0.0507	0.3533
	MIDBERM	80			0.0	100.0	0.0	0.0	0.0	1.8825	0.5396	-0.7739	3.8431	1.8916	1.9823	0.5167	-0.2626	0.4605
	BERM	157			0.0	100.0	0.0	0.0	0.0	2.2823	0.4978	-0.1013	4.5626	2.291	2.2936	0.4544	-0.0502	0.3801
	MIDBEACH	230			0.0	100.0	0.0	0.0	0.0	1.7815	0.908	-0.7326	2.3642	1.7668	2.0909	0.9296	-0.4669	0.5762
	-6		49.721	58.031	2.7	97.3	0.0	0.0	0.0	2.6954	0.5981	-2.4142	11.9005	2.7641	2.8018	0.4645	-0.2467	0.3297
	-12		49.759	57.931	0.0	100.0	0.0	0.0	0.0	2.0958	0.7705	-1.6705	7.3838	2.1443	2.243	0.6654	-0.2521	0.4965
	-18		49.67	57.88	0.0	100.0	0.0	0.0	0.0	2.5109	0.7253	-2.1701	8.2989	2.6248	2.6415	0.6036	-0.2861	0.5151
	-24		49.81	57.86	4.2	93.0	1.5	1.3	2.8	3.1482	0.3349	-4.3969	40.0882	3.1869	3.1998	0.226	-0.213	0.1716
44	BOD	158			0.0	100.0	0.0	0.0	0.0	1.2831	0.5197	0.459	3.1358	1.2711	1.2498	0.5194	0.099	0.5552
	MIDBERM	220			0.0	100.0	0.0	0.0	0.0	1.2278	0.5486	1.0234	5.9938	1.2022	1.1659	0.4942	0.1652	0.5733
	BERM	254			0.0	100.0	0.0	0.0	0.0	1.9885	0.5126	0.0134	2.9268	1.9917	1.9954	0.5123	-0.0227	0.4148
	MIDBEACH	298			0.0	100.0	0.0	0.0	0.0	1.2379	0.8726	0.1247	1.9842	1.2393	1.2287	0.8819	0.0215	0.5905
	TOE	358			0.0	98.3	1.7	0.0	1.7	2.5311	0.5898	-1.6895	6.1606	2.6007	2.6643	0.526	-0.345	0.4386
	-2	388			0.0	100.0	0.0	0.0	0.0	2.7634	0.5131	-0.4719	9.794	2.765	2.7689	0.3726	-0.0729	0.2889
	-6		49.13	57.94	0.0	100.0	0.0	0.0	0.0	2.0637	0.6375	-0.5431	3.2374	2.0764	2.1472	0.6386	-0.1821	0.522
	-12		49.13	57.86	0.0	100.0	0.0	0.0	0.0	2.5005	0.6065	-2.6174	14.4469	2.5727	2.5677	0.4542	-0.0793	0.3369
	-18		49.13	57.79	0.0	92.1	6.4	1.4	7.9	3.1547	0.1647	-0.4542	3.9933	3.1641	3.1635	0.1636	-0.036	0.1212
	-24		49.19	57.65	0.0	48.8	51.2	0.0	51.2	3.0826	0.4522	-4.5479	34.8329	3.1322	3.1855	0.3008	-0.4073	0.2299
45	DUNE CREST	0			0.0	100.0	0.0	0.0	0.0	2.0556	0.3755	-0.7645	8.3274	2.0572	2.0588	0.3443	-0.0134	0.315
	BOD	32			0.0	100.0	0.0	0.0	0.0	1.0211	0.6028	0.3605	2.8533	1.0057	0.9696	0.6056	0.1133	0.7093
	MIDBERM	73			0.0	100.0	0.0	0.0	0.0	1.8607	0.4745	-0.2469	2.8575	1.8574	1.9036	0.482	-0.1394	0.4181
	BERM	88			0.0	100.0	0.0	0.0	0.0	1.5488	0.5363	0.0061	2.8406	1.549	1.5562	0.5336	-0.0065	0.4963
	MIDBEACH	132			0.0	99.4	0.0	0.6	0.6	1.7748	0.6276	-0.2835	2.9553	1.7999	1.7901	0.6204	-0.0161	0.4791
	TOE	200			4.2	95.8	0.0	0.0	0.0	1.5704	1.2342	-0.447	1.901	1.5822	1.8854	1.2548	-0.3346	0.6211
	-2				0.0	100.0	0.0	0.0	0.0	2.3935	0.7431	-1.9026	8.217	2.4651	2.5626	0.6252	-0.3189	0.4421
	-6		48.457	57.766	0.0	100.0	0.0	0.0	0.0	2.1557	0.7714	-0.7127	2.8634	2.1734	2.3036	0.7887	-0.2717	0.5108
	-12		48.494	57.722	0.0	100.0	0.0	0.0	0.0	2.6159	0.4781	-2.0956	14.3914	2.6472	2.6337	0.4042	-0.0164	0.2767
	-18		48.521	57.641	0.0	98.4	1.4	0.2	1.6	3.1056	0.2652	-1.2504	7.2657	3.1155	3.1579	0.2585	-0.2702	0.1737
	-24		48.582	57.444	0.0	95.6	3.5	0.9	4.4	3.0745	0.4179	-4.2325	32.0613	3.1182	3.1668	0.2797	-0.3407	0.2015
46	DUNE FACE	54			0.0	98.9	0.0	1.1	1.1	1.9572	0.4919	-0.0068	2.7018	1.9577	1.967	0.4923	-0.0272	0.3974
	BOD	69			0.0	100.0	0.0	0.0	0.0	1.9286	0.4033	-0.1059	3.849	1.9281	1.9434	0.3936	-0.0422	0.3633
	MIDBERM	89			0.0	99.5	0.0	0.5	0.5	1.9243	0.4265	-0.043	3.0114	1.9215	1.9467	0.4221	-0.0702	0.3724
	BERM	103			0.0	100.0	0.0	0.0	0.0	2.0078	0.3892	0.1078	3.2517	2.0019	2.0106	0.3879	-0.0271	0.3601
	MIDBEACH	147			0.0	98.2	0.0	1.8	1.8	2.2872	0.5042	-0.3262	2.5687	2.2865	2.3619	0.5128	-0.2001	0.3658
	TOE	219			2.6	96.3	0.0	1.1	1.1	1.9564	0.9466	-0.8922	3.4127	1.9979	2.1667	0.9251	-0.3148	0.616
	-2	266			0.0	100.0	0.0	0.0	0.0	2.6456	0.529	-1.1355	4.7877	2.688	2.7308	0.4957	-0.2261	0.3451
	-6		47.881	57.569	0.0	100.0	0.0	0.0	0.0	2.3792	0.4724	-0.4086	2.8825	2.3862	2.4313	0.4739	-0.1458	0.3462
	-12		47.91	57.526	0.0	99.2	0.8	0.0	0.8	2.8998	0.2802	-2.622	33.9126	2.9089	2.9129	0.2535	-0.0571	0.1704
	-18		47.928	57.444	0.3	93.5	6.2	0.0	6.2	2.9173	0.4536	-1.3319	5.8932	2.9531	3.0252	0.4021	-0.2955	0.2615
	-24		47.908	57.221	0.0	93.0	5.3	1.7	7.0	2.9705	0.366	-0.8422	4.2208	2.9828	3.0404	0.3471	-0.239	0.228

1 aug 1996																		
Profile	Location	Dist (ft)	Latitude	Longitude	%grvl	%sand	%silt	%clay	%mud	M1	M2	M3	M4	Mn	Md	Sorting	Skewness	Kurtosis
			36 deg	75 deg										(Phi)	(Phi)	(Phi)		
			minutes	minutes														
47	-6		46.997	57.348	0.0	99.4	0.0	0.6	0.6	2.2554	0.6649	-0.5514	3.2094	2.2749	2.3321	0.6684	-0.1442	0.4679
	-12		47.009	57.246	1.0	97.7	1.3	0.0	1.3	3.0236	0.2797	-0.5281	2.9449	3.0303	3.064	0.2816	-0.1846	0.188
	-18		47.016	57.217	0.5	95.3	3.7	0.5	4.2	3.0265	0.5102	-2.2635	11.1204	3.0733	3.1526	0.4197	-0.3396	0.2711
	-24		47.074	57.014	0.0	93.9	4.3	1.8	6.1	3.1926	0.3691	-4.3712	38.9583	3.2121	3.2184	0.2778	-0.0768	0.1726
48	DUNE CREST	77			0.0	100.0	0.0	0.0	0.0	2.1453	0.3349	-2.7768	31.2847	2.1402	2.1211	0.258	0.165	0.2544
	BOD	107			0.0	100.0	0.0	0.0	0.0	1.5771	0.4622	0.4043	3.3617	1.5469	1.507	0.4604	0.1392	0.4892
	MIDBERM	130			0.0	100.0	0.0	0.0	0.0	1.9438	0.3875	-0.0909	4.107	1.9442	1.9564	0.3723	-0.0491	0.3527
	BERM	150			0.0	100.0	0.0	0.0	0.0	2.1552	0.5293	-1.9832	14.0231	2.1799	2.1769	0.4251	0.017	0.3693
	MIDBEACH	177			0.0	97.6	1.3	1.1	2.4	1.5743	0.4163	-0.3327	7.7990	1.5827	1.5596	0.3646	0.0915	0.4213
	TOE	300			0.0	100.0	0.0	0.0	0.0	2.2003	0.7293	-0.0755	1.9982	2.2059	2.1829	0.7636	0.0127	0.4353
	-2	412			0.0	99.3	0.0	0.7	0.7	2.5323	0.6467	-1.1616	4.5615	2.5709	2.6619	0.6102	-0.2955	0.396
	-6		46.023	56.986	0.0	99.8	0.2	0.0	0.2	2.9404	0.3813	-0.5532	3.3216	2.9501	2.9829	0.3773	-0.146	0.2509
	-12		46.062	56.979	0.0	99.9	0.1	0.0	0.1	2.7814	0.4642	-1.8528	8.2184	2.8343	2.8478	0.3771	-0.1891	0.2911
	-18		46.08	56.865	0.0	98.1	1.0	0.9	1.9	2.693	0.864	-0.796	2.1171	2.6865	3.1312	0.8689	-0.6527	0.3951
	-24		46.102	56.697	0.4	97.3	2.2	0.1	2.3	2.6921	0.7239	-2.0856	9.3323	2.7693	2.8013	0.5888	-0.2197	0.4163
49	DUNE CREST	70			0.0	100.0	0.0	0.0	0.0	1.4597	0.6158	-0.6402	3.7268	1.4808	1.5488	0.5985	-0.2419	0.6454
	BOD	104			0.0	100.0	0.0	0.0	0.0	1.8138	0.4172	-0.0157	3.1096	1.8106	1.8203	0.4188	-0.0185	0.4108
	MIDBERM	148			0.0	100.0	0.0	0.0	0.0	1.958	0.417	0.3586	4.4445	1.9491	1.9729	0.3945	-0.0476	0.3902
	BERM	178			0.0	100.0	0.0	0.0	0.0	2.104	0.3975	-0.022	3.0157	2.1053	2.1094	0.3977	-0.0257	0.3356
	MIDBEACH	228			0.0	100.0	0.0	0.0	0.0	1.5169	0.7689	0.1925	2.388	1.519	1.4712	0.7944	0.0763	0.6057
	TOE	337			0.0	100.0	0.0	0.0	0.0	1.7583	1.1652	-1.0327	3.588	1.8884	1.965	0.9843	-0.1801	0.5873
	-2	393			0.0	100.0	0.0	0.0	0.0	2.7286	0.5534	-1.7841	10.4823	2.7536	2.8315	0.5018	-0.2699	0.3159
	-6		45.613	56.895	0.0	100.0	0.0	0.0	0.0	2.3362	0.6722	-0.4722	3.0247	2.3641	2.369	0.6803	-0.0694	0.4377
	-12		45.653	56.754	0.0	98.6	1.2	0.2	1.4	2.9948	0.3635	-3.2032	30.1904	3.004	3.0274	0.3008	-0.092	0.1982
	-18		45.663	56.704	0.0	98.5	1.5	0.0	1.5	3.0286	0.5858	-3.5801	21.259	3.1163	3.1362	0.4116	-0.2704	0.3181
	-24		45.658	56.451	0.0	95.3	4.0	0.7	4.7	3.0062	0.5341	-2.7349	14.5795	3.0604	3.1535	0.4135	-0.4313	0.2999
50	BASE OF BULK	146			0.0	100.0	0.0	0.0	0.0	2.0346	0.34	0.1621	3.3627	2.0367	2.0158	0.3288	0.0913	0.3129
	MIDBEACH	186			0.0	100.0	0.0	0.0	0.0	2.1077	0.5262	-0.7471	5.5013	2.131	2.1396	0.5101	-0.0493	0.3737
	TOE	285			0.0	100.0	0.0	0.0	0.0	1.3917	1.2057	-0.6614	2.3602	1.3642	1.6987	1.2698	-0.3621	0.7925
	-2	342			0.0	100.0	0.0	0.0	0.0	2.4753	0.6222	-0.8724	3.4587	2.5082	2.5964	0.6102	-0.2796	0.3874
	-6		45.192	56.698	0.0	100.0	0.0	0.0	0.0									
	-12		45.254	56.686	0.0	100.0	0.0	0.0	0.0	2.8613	0.5148	-2.224	11.2057	2.9248	2.975	0.4289	-0.346	0.3493
	-18		45.261	56.561	7.2	91.7	1.0	0.0	1.0	2.9851	0.7246	-3.0222	13.6225	3.0898	3.1846	0.5026	-0.4837	0.3945
	-24		45.31	56.389	0.0	86.2	11.6	2.2	13.8	3.2197	0.3457	-3.0893	18.9761	3.263	3.2466	0.2542	-0.0536	0.1859

	16 April 1997																	
Profile	Location	Dist (ft)	Latitude 36 deg minutes	Longitude 75 deg minutes	%grvl	%sand	%silt	%clay	%mud	M1	M2	M3	M4	Mn (Phi)	Md (Phi)	Sorting (Phi)	Skewness	Kurtosis
43	DUNE CREST	30			0.00	100.00	0.00	0.00	0.00	1.9080	0.5645	0.5156	4.6773	1.8735	1.9085	0.5152	-0.0311	0.4780
	BOD	42			0.00	100.00	0.00	0.00	0.00	1.7692	0.2988	-0.1808	11.7862	1.7651	1.7676	0.2547	-0.0184	0.2876
	MIDBERM	80			0.00	100.00	0.00	0.00	0.00	1.4160	0.5619	1.2438	7.0392	1.3775	1.3591	0.4647	0.0846	0.5315
	BERM	149			0.00	100.00	0.00	0.00	0.00	0.9941	0.5252	0.8298	5.1075	0.9524	0.9520	0.5051	0.0426	0.6636
	MIDBEACH	184			0.00	100.00	0.00	0.00	0.00	0.5085	0.7909	1.4009	5.7411	0.4291	0.3579	0.7236	0.2543	1.2422
	TOE	219			0.00	100.00	0.00	0.00	0.00	0.3634	1.1115	0.7683	2.6586	0.3752	0.1271	1.0990	0.3529	1.1142
	-2	247			0.00	100.00	0.00	0.00	0.00	1.8135	0.4326	-0.0391	4.5345	1.7949	1.8647	0.4048	-0.2145	0.3990
	-6		49.721	58.031	0.00	97.84	2.16	0.00	2.16	3.1057	0.2093	-0.3136	3.6234	3.1049	3.1198	0.2088	-0.1002	0.1595
	-12		49.759	57.931	0.00	100.00	0.00	0.00	0.00	2.3781	0.6085	-1.4169	7.2670	2.4192	2.4877	0.5317	-0.2763	0.4368
	-18		49.67	57.88	0.00	100.00	0.00	0.00	0.00	2.7343	0.4788	-3.6640	22.8869	2.7889	2.8223	0.3247	-0.2585	0.2515
	-24		49.81	57.86	0.90	79.44	19.66	0.00	19.66	2.2614	0.4111	-1.2832	8.4546	2.2863	2.2497	0.3547	0.0512	0.3409
44	BOD	158			0.00	100.00	0.00	0.00	0.00	1.5574	0.3543	0.7766	6.8652	1.5512	1.5587	0.3164	-0.0372	0.3747
	MIDBERM	220			0.00	100.00	0.00	0.00	0.00	1.2897	0.5185	0.6564	6.4899	1.2636	1.2991	0.4645	-0.0899	0.5451
	BERM	266			0.00	100.00	0.00	0.00	0.00	1.3706	0.3973	0.5654	6.2109	1.3638	1.3568	0.3578	0.0129	0.4382
	MIDBEACH	298			0.00	100.00	0.00	0.00	0.00	0.6972	0.6891	1.5980	7.1887	0.6503	0.6554	0.5771	0.0940	0.8445
	toe	368			0.00	100.00	0.00	0.00	0.00	1.3408	0.5174	-0.4607	4.1608	1.3558	1.3969	0.4720	-0.1728	0.5522
	-2	533			0.00	99.98	0.02	0.00	0.02	2.3652	0.4179	-0.0834	4.1866	2.3767	2.3322	0.3968	0.1352	0.3363
	-6		49.13	57.94	0.35	99.65	0.00	0.00	0.00	1.3717	0.7643	-0.6259	2.9300	1.3615	1.5461	0.7547	-0.3225	0.5794
	-12		49.13	57.86	1.61	95.67	1.72	1.00	2.72	2.9177	0.5015	-3.4854	19.1546	2.9769	3.0609	0.3275	-0.5160	0.2530
	-18		49.13	57.79	0.00	93.13	6.87	0.00	6.87	3.1675	0.1397	-0.3364	3.7311	3.1703	3.1775	0.1415	-0.1220	0.1026
	-24		49.19	57.65	0.00	88.73	11.27	0.00	11.27	2.9789	0.4069	-6.3726	60.8802	3.0110	3.0410	0.2386	-0.2322	0.1782
45	DUNE CREST	0			0.00	100.00	0.00	0.00	0.00	1.5872	0.4381	-1.2709	14.5722	1.5975	1.5960	0.3332	0.0076	0.3823
	BOD	18			0.00	100.00	0.00	0.00	0.00	1.3134	0.4001	0.7259	10.2451	1.2908	1.3031	0.3282	-0.0075	0.3959
	MIDBERM	75			16.11	83.89	0.00	0.00	0.00	0.9821	0.6079	0.0816	3.2591	0.9378	1.0151	0.6170	-0.1378	0.6899
	BERM/CUSP	149			0.00	100.00	0.00	0.00	0.00	1.4212	0.3929	-0.0573	3.1206	1.4096	1.4459	0.3949	-0.1025	0.4369
	MIDBEACH	165			0.00	100.00	0.00	0.00	0.00	0.1976	0.7145	0.6644	4.2864	0.1220	0.1281	0.6975	0.0351	0.9956
	TOE	214			0.00	100.00	0.00	0.00	0.00	1.6019	0.4037	-0.8620	11.5745	1.6093	1.5970	0.3449	0.0432	0.3679
	-6		48.457	57.766	0.00	100.00	0.00	0.00	0.00	2.4629	0.6415	-1.4214	5.0021	2.5232	2.6425	0.5760	-0.4149	0.4146
	-12		48.494	57.722	2.18	96.47	1.35	0.00	1.35	2.3982	0.6717	-2.4620	14.2013	2.4524	2.4464	0.4960	-0.0619	0.3772
	-18		48.521	57.641	0.00	96.55	3.37	0.08	3.45	2.7498	0.4082	-1.2234	5.989	2.777	2.7933	0.3663	-0.1448	0.2501
	-24		48.582	57.444	0.00	90.80	7.32	1.87	9.20	2.9504	0.4286	-4.4883	35.8809	2.9833	3.0281	0.2863	-0.2894	0.2056
46	DUNE FACE	54			0.00	100.00	0.00	0.00	0.00	1.2579	0.3709	-1.0612	10.7880	1.2694	1.2988	0.3197	-0.1579	0.4206
	BOD	70			0.00	100.00	0.00	0.00	0.00	1.2022	0.4044	-0.0142	6.8774	1.2078	1.2428	0.3369	-0.1161	0.4580
	MIDBERM	89			0.00	100.00	0.00	0.00	0.00	1.1944	0.3490	2.4014	15.7701	1.1654	1.1529	0.2773	0.1404	0.4267
	BERM	103			6.24	93.76	0.00	0.00	0.00	1.1768	0.3390	1.6546	14.4142	1.1644	1.1664	0.2769	0.0373	0.4140
	MIDBEACH	246			0.00	100.00	0.00	0.00	0.00	1.3430	0.3937	0.0861	4.1844	1.3378	1.3240	0.3760	0.0636	0.4766
	TOE	267			0.00	100.00	0.00	0.00	0.00	0.9264	0.4876	-0.2446	5.6645	0.9160	0.9212	0.4325	-0.0300	0.6115
	-2				0.00	100.00	0.00	0.00	0.00	1.5533	0.5191	-0.0205	3.7481	1.5546	1.5755	0.4997	-0.0701	0.5201
	-6		47.881	57.569	2.08	97.92	0.00	0.00	0.00	2.3951	0.7673	-1.9063	6.1139	2.5013	2.6229	0.6669	-0.4974	0.5937
	-12		47.91	57.526	0.00	98.82	1.18	0.00	1.18	2.7336	0.5919	-3.7272	24.5379	2.7965	2.7791	0.3842	-0.0456	0.2908
	-18		47.928	57.444	1.65	92.47	4.78	1.10	5.88	2.7456	0.4739	-2.5694	16.7073	2.7893	2.8031	0.3693	-0.1432	0.2640
	-24		47.908	57.221	0.00	96.25	3.75	0.00	3.75	2.7460	0.4440	-2.1278	13.7757	2.7762	2.7953	0.3613	-0.1597	0.2432

Profile	Location	Dist (ft)	Latitude	Longitude	%grvl	%sand	%silt	%clay	%mud	M1	M2	M3	M4	Mn	Md	Sorting	Skewness	Kurtosis
	16 April 1997		36 deg minutes	75 deg minutes										(Phi)	(Phi)	(Phi)		
47	BOD	80			0.00	100.00	0.00	0.00	0.00	1.1817	0.4904	0.2401	6.3521	1.1922	1.2486	0.4333	-0.2302	0.5875
	MIDBERM	146			0.00	100.00	0.00	0.00	0.00	1.3042	0.5902	-0.3156	8.8395	1.2877	1.2686	0.3931	0.3107	0.3107
	BERM	224			0.00	100.00	0.00	0.00	0.00	1.2821	0.2611	-1.3279	14.3626	1.2849	1.2904	0.2505	-0.0124	0.3330
	TOE	348			0.00	100.00	0.00	0.00	0.00	0.2925	0.7433	0.6223	3.6796	0.3206	0.2589	0.7604	0.0799	1.0924
	-2	480			0.00	100.00	0.00	0.00	0.00	1.7206	0.5313	-0.2883	4.5997	1.7294	1.7283	0.4928	-0.0159	0.4735
	-6		46.997	57.348	0.43	99.57	0.00	0.00	0.00	1.5746	0.6860	-0.3830	3.9634	1.5792	1.6535	0.6672	-0.2081	0.7085
	-12		47.009	57.246	0.00	79.03	20.97	0.00	20.97	2.7506	0.4818	-3.1572	19.2570	2.7955	2.8338	0.3467	-0.2509	0.2509
	-18		47.016	57.217	0.43	96.65	2.17	0.74	2.91	2.8639	0.3768	-2.4763	14.3380	2.9020	2.9007	0.2845	-0.0996	0.2073
	-24		47.074	57.014	0.00	97.27	2.73	0.00	2.73	2.7706	0.3573	-2.0882	18.1177	2.7971	2.7844	0.2943	-0.0090	0.2185
48	DUNE CREST	77			0.00	100.00	0.00	0.00	0.00	1.9626	0.2722	-0.0526	3.4920	1.9605	1.9662	0.2681	-0.0336	0.2664
	BOD	108			0.00	100.00	0.00	0.00	0.00	1.5921	0.3939	-0.3260	10.3059	1.5963	1.6067	0.3510	-0.0522	0.3803
	MIDBERM	130			0.00	100.00	0.00	0.00	0.00	1.2791	0.4137	0.2033	4.7981	1.2724	1.2715	0.3904	0.0401	0.4515
	BERM/CUSP	225			0.00	100.00	0.00	0.00	0.00	1.3000	0.5352	0.4100	3.3961	1.2869	1.2895	0.5393	0.0107	0.5487
	TOE	297			0.00	100.00	0.00	0.00	0.00	1.7175	0.6923	-0.4933	3.1082	1.7055	1.8651	0.6754	-0.3378	0.5485
	-2	412			0.00	100.00	0.00	0.00	0.00	2.0887	0.5529	-2.2729	12.4314	2.1463	2.1576	0.4375	-0.1223	0.4188
	-6		46.023	56.986	0.32	99.07	0.61	0.00	0.61	2.3413	0.6090	-0.8834	3.2132	2.3456	2.5159	0.6131	-0.4023	0.4232
	-12		46.062	56.979	0.00	97.47	1.89	0.64	2.53	2.9917	0.3067	-8.3865	111.0962	3.0101	3.0173	0.1849	-0.1074	0.1329
	-18		46.08	56.865	0.61	96.84	1.90	0.65	2.55	2.5969	0.6389	-2.0262	7.4993	2.6813	2.7855	0.5258	-0.4838	0.4411
	-24		46.102	56.697	0.51	98.82	0.67	0.00	0.67	2.4465	0.3988	-0.8735	7.6859	2.4681	2.4121	0.3412	0.2218	0.2820
49	DUNE CREST	70			0.00	100.00	0.00	0.00	0.00	1.5928	0.4000	-0.5266	6.0195	1.6077	1.5879	0.3601	0.0444	0.4132
	BOD	104			0.00	100.00	0.00	0.00	0.00	1.6810	0.4042	0.5886	7.6079	1.6662	1.6682	0.3507	0.0121	0.3700
	MIDBERM	148			0.00	100.00	0.00	0.00	0.00	1.5460	0.5294	-1.0779	12.3236	1.5605	1.5603	0.3823	0.0013	0.4182
	BERM	178			0.00	100.00	0.00	0.00	0.00	1.1900	0.4814	1.6939	8.3677	1.1499	1.1348	0.4150	0.1596	0.5259
	MIDBEACH	228			0.00	100.00	0.00	0.00	0.00	1.5472	0.4830	0.5255	4.6949	1.5305	1.5608	0.4623	-0.0734	0.4515
	TOE	337			0.00	100.00	0.00	0.00	0.00	1.5438	0.6682	-1.0840	5.0533	1.5685	1.6801	0.6074	-0.3006	0.5773
	-2				0.24	96.58	3.18	0.00	3.18	2.2900	0.4529	-0.9323	5.7570	2.3127	2.3489	0.4262	-0.1600	0.3449
	-6		45.613	56.895	0.00	97.44	2.56	0.00	2.56	2.2334	0.5979	-1.4629	5.9600	2.2819	2.3498	0.5401	-0.3007	0.4678
	-12		45.653	56.754	0.22	97.27	2.51	0.00	2.51	2.8340	0.3726	-1.8896	8.2936	2.8708	2.9120	0.3089	-0.3286	0.2383
	-18		45.663	56.704	0.17	99.13	0.70	0.00	0.70	2.9928	0.4097	-6.1804	47.1480	3.0447	3.0518	0.1605	-0.1906	0.1228
	-24		45.658	56.451	0.00	97.69	2.31	0.00	2.31	2.9247	0.3131	-5.2435	58.7097	2.9563	2.9502	0.2059	-0.0724	0.1580
50	BASE OF BULK	146			0.00	100.00	0.00	0.00	0.00	1.3184	0.2459	1.5241	12.0964	1.3123	1.3029	0.2259	0.0809	0.3187
	MIDBEACH	188			0.00	100.00	0.00	0.00	0.00	1.4157	0.3860	0.0648	2.9550	1.4072	1.4078	0.3901	0.0144	0.4472
	TOE	301			1.81	98.19	0.00	0.00	0.00	0.0648	0.7442	1.1927	3.6442	0.0334	-0.1731	0.7326	0.4893	2.3646
	-2				0.00	93.89	1.83	4.28	6.11	2.0462	0.7856	-1.3801	5.2857	2.1344	2.1332	0.7894	-0.2154	0.6932
	-6		45.192	56.698	0.00	100.00	0.00	0.00	0.00	1.8185	0.6904	-0.2433	2.5077	1.8167	1.8810	0.6937	-0.1303	0.4871
	-12		45.254	56.686	0.76	98.44	0.81	0.00	0.81	2.3932	0.5874	-1.3394	4.9015	2.4652	2.5099	0.5315	-0.3035	0.5056
	-18		45.261	56.561	0.39	96.98	2.63	0.00	2.63	2.8695	0.4072	-6.3759	55.8555	2.9007	2.9028	0.1976	-0.0343	0.1440
	-24		45.31	56.389	0.53	99.47	0.00	0.00	0.00	2.8595	0.8227	-2.9762	11.0385	3.0234	3.1183	0.6581	-0.7039	0.7211

Oct 1997																		
Profile	Location	Dist (ft)	Latitude	Longitude	%grvl	%sand	%silt	%clay	%mud	M1	M2	M3	M4	Mn	Md	Sorting	Skewness	Kurtosis
			36 deg	75 deg										(Phi)	(Phi)	(Phi)		
			minutes	minutes														
43	DUNE CREST	30			0.00	100.00	0.00	0.00	0.00	1.5558	0.3892	0.9839	4.6905	1.5529	1.4975	0.3622	0.2662	0.4566
	BOD	42			0.00	100.00	0.00	0.00	0.00	2.0535	0.3116	0.0045	3.5536	2.0545	2.0519	0.3071	0.0083	0.2908
	MIDBERM	119			0.00	99.75	0.25	0.00	0.25	1.4870	0.6497	-0.1597	2.4333	1.4949	1.5370	0.6466	-0.0975	0.5472
	BERM	148			0.00	100.00	0.00	0.00	0.00	1.7120	0.5585	-0.8021	3.5606	1.7355	1.8010	0.5420	-0.2204	0.4945
	MIDBEACH	180			0.00	100.00	0.00	0.00	0.00	1.8557	0.8014	-1.1036	3.6042	1.9138	2.1320	0.7806	-0.4728	0.5679
	TOE	342			0.00	99.07	0.93	0.00	0.93	2.2312	0.6479	-1.3252	4.7469	2.2743	2.3627	0.5917	-0.3527	0.5425
	-2	560			0.00	99.45	0.55	0.00	0.55	2.8843	0.3793	-3.5095	25.7590	2.9123	2.9104	0.2774	0.0001	0.1928
	-6		49.721	58.031	0.00	100.00	0.00	0.00	0.00	2.7213	0.3446	-0.5207	2.6481	2.7267	2.7446	0.3493	-0.1194	0.2229
	-12		49.759	57.931	0.00	100.00	0.00	0.00	0.00	2.7844	0.4639	-3.4256	19.1380	2.8468	2.8474	0.2861	-0.1377	0.2241
	-18		49.67	57.88	0.00	100.00	0.00	0.00	0.00	2.7679	0.6382	-2.8126	12.0441	2.8819	2.9604	0.4562	-0.5225	0.4060
	-24		49.81	57.86	0.00	100.00	0.00	0.00	0.00	2.9907	0.4283	-5.7527	47.9308	3.0278	3.0481	0.2453	-0.1567	0.1735
44	BOD	158			0.00	100.00	0.00	0.00	0.00	1.4515	0.3802	-0.1619	3.3433	1.4506	1.4485	0.3836	0.0152	0.4123
	MIDBERM	230			0.00	100.00	0.00	0.00	0.00	1.2995	0.6465	-1.2347	6.1244	1.3420	1.3796	0.5792	-0.2059	0.7103
	BERM	264			0.00	100.00	0.00	0.00	0.00	1.2077	0.6025	0.2284	3.8040	1.2279	1.2589	0.5653	-0.0990	0.6105
	MIDBEACH	313			0.00	100.00	0.00	0.00	0.00	2.0647	0.5387	-1.0081	4.0218	2.0952	2.1680	0.5173	-0.2751	0.4169
	TOE	370			0.00	99.76	0.24	0.00	0.24	2.7382	0.3106	-0.7344	3.5345	2.7531	2.7819	0.3079	-0.1922	0.2245
	-2	461			0.00	99.84	0.16	0.00	0.16	2.4995	0.6236	-1.8336	7.0228	2.5678	2.6563	0.5513	-0.3902	0.4137
	offshore	545			0.00	99.75	0.25	0.00	0.25	2.7129	0.4062	-0.7040	2.7116	2.7203	2.7844	0.4132	-0.2738	0.2637
	-6		49.13	57.94	0.00	100.00	0.00	0.00	0.00	1.9801	0.5972	-0.5041	4.1366	1.9954	1.9938	0.5906	-0.0169	0.5324
	-12		49.13	57.86	0.00	100.00	0.00	0.00	0.00	3.1025	0.2080	-0.6949	4.7742	3.1117	3.1117	0.1952	-0.0789	0.1491
	-18		49.13	57.79	0.00	97.02	2.94	0.04	2.98	3.1405	0.2201	-0.9637	5.4741	3.1635	3.1580	0.2013	-0.0734	0.1629
	-24		49.19	57.65	0.00	99.86	0.09	0.05	0.14	3.0223	0.4539	-2.7004	20.1687	3.0377	3.1237	0.3872	-0.3510	0.2895
45	DUNE CREST	0			0.00	100.00	0.00	0.00	0.00	1.7806	0.3829	-0.7381	3.5544	1.7939	1.8457	0.3787	-0.2324	0.3785
	BOD	32			0.00	100.00	0.00	0.00	0.00	1.3951	0.4460	-0.2359	2.6476	1.3910	1.4351	0.4539	-0.1211	0.4636
	MIDBERM	78			4.74	95.26	0.00	0.00	0.00	0.9603	0.7605	-0.8664	2.8235	0.9841	1.1875	0.7597	-0.4242	0.7396
	BERM/CUSP	135			0.00	100.00	0.00	0.00	0.00	1.4426	0.3616	0.1888	2.6170	1.4402	1.4167	0.3680	0.0963	0.4130
	MIDBEACH	171			0.00	100.00	0.00	0.00	0.00	1.9096	0.5914	-0.3230	3.0935	1.9160	1.9592	0.5900	-0.1237	0.4847
	TOE	233			9.04	89.05	1.91	0.00	1.91	2.4862	0.3421	-0.6184	3.0333	2.4981	2.5443	0.3464	-0.2220	0.2646
	-2	407			0.00	99.83	0.17	0.00	0.17	2.7541	0.5499	-3.5882	22.8011	2.8204	2.8842	0.3867	-0.3797	0.2835
	-6		48.457	57.766	0.00	100.00	0.00	0.00	0.00	2.1146	0.5974	-0.8915	4.0626	2.1409	2.2035	0.5782	-0.2055	0.4768
	-12		48.494	57.722	0.00	100.00	0.00	0.00	0.00	2.7500	0.5038	-2.2938	12.5567	2.8016	2.8326	0.4130	-0.2417	0.2890
	-18		48.521	57.641	0.00	99.85	0.15	0.00	0.15	3.1534	0.2223	-0.3194	3.3889	3.1520	3.1745	0.2248	-0.1432	0.1592
	-24		48.582	57.444	0.17	99.59	0.25	0.00	0.25	3.1496	0.2185	-0.7241	3.7339	3.1564	3.1799	0.2170	-0.2122	0.1546
46	DUNE FACE	54			0.00	100.00	0.00	0.00	0.00	0.3247	0.6867	0.8111	5.4721	0.3232	0.3291	0.6359	-0.0126	0.9631
	BOD	73			0.00	100.00	0.00	0.00	0.00	1.3375	0.4131	-3.9969	23.9836	1.3906	1.3745	0.2133	-0.0113	0.3210
	MIDBERM	102			2.39	97.61	0.00	0.00	0.00	1.2034	0.2880	-0.4513	5.4642	1.2157	1.2351	0.2653	-0.1182	0.3863
	BERM	158			0.00	100.00	0.00	0.00	0.00	1.1167	0.3168	-0.0177	3.4259	1.1102	1.1061	0.3021	0.0359	0.4331
	MIDBEACH	198			0.00	100.00	0.00	0.00	0.00	1.3247	0.4998	-1.1754	5.9427	1.3412	1.3665	0.4377	-0.1473	0.5394
	TOE	295			1.85	97.79	0.37	0.00	0.37	2.6529	0.3839	-1.7790	8.9909	2.6887	2.6998	0.3367	-0.1561	0.2717
	-2	451			0.00	99.91	0.09	0.00	0.09	2.6950	0.4937	-2.7840	18.8403	2.7380	2.7841	0.4132	-0.2768	0.3029
	-6		47.881	57.569	0.00	100.00	0.00	0.00	0.00	2.3446	0.4790	-0.4739	3.0755	2.3653	2.3849	0.4791	-0.0910	0.3517
	-12		47.91	57.526	0.00	100.00	0.00	0.00	0.00	2.9026	0.4491	-2.6126	15.7725	2.9447	3.0181	0.3489	-0.3690	0.2370
	-18		47.928	57.444	0.00	99.94	0.06	0.00	0.06	2.9453	0.3009	-0.4049	2.2186	2.9481	3.0000	0.3064	-0.2423	0.1894
	-24		47.908	57.221	0.00	99.61	0.39	0.00	0.39	2.8536	0.3722	-1.3836	7.0493	2.8783	2.9087	0.3266	-0.1717	0.2214

Oct 1997																		
Profile	Location	Dist (ft)	Latitude	Longitude	%grvl	%sand	%silt	%clay	%mud	M1	M2	M3	M4	Mn	Md	Sorting	Skewness	Kurtosis
			36 deg	75 deg										(Phi)	(Phi)	(Phi)		
			minutes	minutes														
47	BOD	76			0.00	100.00	0.00	0.00	0.00	1.3132	0.3314	3.5335	26.0432	1.2689	1.2950	0.1582	-0.1846	0.3186
	MIDBERM	134			3.13	96.88	0.00	0.00	0.00	1.4491	0.4670	0.8252	7.2698	1.4258	1.4343	0.3832	0.0021	0.4764
	BERM/CUSP	257			0.00	100.00	0.00	0.00	0.00	1.8315	0.6761	0.4321	3.3026	1.8111	1.7685	0.6622	0.1591	0.6570
	MIDBEACH	302			0.00	100.00	0.00	0.00	0.00	2.0631	0.4613	-0.6512	4.2386	2.0825	2.1125	0.4331	-0.1450	0.3805
	TOE	351			24.18	75.82	0.00	0.00	0.00	2.0771	0.8071	-1.2798	4.1065	2.1346	2.3419	0.7648	-0.4854	0.5734
	-2	537			0.00	99.84	0.16	0.00	0.16	2.6669	0.3940	-1.0991	6.5967	2.6852	2.6992	0.3789	-0.1227	0.2571
	-6		46.997	57.348	0.00	100.00	0.00	0.00	0.00	2.5509	0.5244	-0.1503	1.9058	2.5569	2.5625	0.5401	-0.0526	0.2974
	-12		47.009	57.246	0.00	100.00	0.00	0.00	0.00	3.0003	0.3334	-2.9112	22.5741	3.0178	3.0637	0.2745	-0.3338	0.2040
	-18		47.016	57.217	0.00	100.00	0.00	0.00	0.00	3.1060	0.3516	-5.6364	57.0287	3.1336	3.1606	0.2361	-0.2200	0.1694
	-24		47.074	57.014	0.00	99.94	0.06	0.00	0.06	3.0927	0.2185	0.3271	3.4362	3.0859	3.0815	0.2195	0.0629	0.1577
48	DUNE CREST	77			0.00	100.00	0.00	0.00	0.00	2.4845	0.3410	1.8388	7.5239	2.4511	2.4191	0.2660	0.2874	0.2601
	BOD	108			0.00	100.00	0.00	0.00	0.00	2.1295	0.6655	1.2037	3.8694	2.0265	2.0029	0.5967	0.2473	0.6184
	MIDBERM	130			0.00	100.00	0.00	0.00	0.00	2.0502	0.4362	-1.1706	11.7417	2.0516	2.0370	0.4084	0.0698	0.3298
	BERM	194			0.00	100.00	0.00	0.00	0.00	1.7491	0.4216	0.1109	2.8522	1.7477	1.7426	0.4235	0.0219	0.3852
	MIDBEACH	233			0.00	99.91	0.09	0.00	0.09	1.9734	0.4657	-0.3984	2.8140	2.0014	2.0363	0.4571	-0.1566	0.3795
	TOE	314			0.00	99.90	0.10	0.00	0.10	2.2298	0.6823	-1.3669	4.5838	2.2625	2.4250	0.6447	-0.4494	0.5113
	-2	547			0.00	99.94	0.06	0.00	0.06	2.7790	0.4082	-2.0000	8.4823	2.8217	2.8780	0.3364	-0.3448	0.2427
	-6		46.023	56.986	0.00	100.00	0.00	0.00	0.00	1.9545	0.7534	-0.4636	3.0964	1.9558	2.0440	0.7549	-0.1463	0.5868
	-12		46.062	56.979	0.00	100.00	0.00	0.00	0.00	2.4040	0.6596	-1.6326	7.3138	2.4336	2.5662	0.6091	-0.3590	0.3707
	-18		46.08	56.865	0.00	99.79	0.21	0.00	0.21	2.7172	0.6667	-1.7185	5.6052	2.7613	2.9526	0.5851	-0.5821	0.4190
	-24		46.102	56.697	0.00	100.00	0.00	0.00	0.00	2.4822	0.5637	-0.7792	6.7315	2.5093	2.4241	0.5513	0.1734	0.3312
49	DUNE CREST	61			0.80	99.20	0.00	0.00	0.00	1.9110	0.3782	-1.5719	10.2662	1.9229	1.9469	0.3275	-0.1338	0.3319
	BOD	104			0.00	100.00	0.00	0.00	0.00	1.9319	0.3488	-0.3605	4.0462	1.9359	1.9559	0.3305	-0.1150	0.3359
	MIDBERM	136			0.00	100.00	0.00	0.00	0.00	1.8693	0.4892	-0.9838	5.4397	1.8859	1.9514	0.4424	-0.2699	0.4430
	BERM	206			0.00	100.00	0.00	0.00	0.00	1.9143	0.2763	0.2586	4.3421	1.9147	1.9149	0.2619	-0.0038	0.2693
	MIDBEACH	247			0.00	100.00	0.00	0.00	0.00	2.0124	0.4670	0.1711	2.5043	2.0134	1.9883	0.4853	0.0817	0.3968
	TOE	435			0.00	100.00	0.00	0.00	0.00	2.6971	0.5572	-3.2302	16.3504	2.7832	2.8209	0.3740	-0.3367	0.3179
	-2	576			0.00	99.96	0.04	0.00	0.04	2.8911	0.5144	-5.2799	33.4376	2.9619	2.9635	0.1964	-0.1172	0.1484
	-6		45.613	56.895	0.00	100.00	0.00	0.00	0.00	2.2706	0.6251	-0.5791	5.2877	2.2927	2.3518	0.5493	-0.2313	0.4468
	-12		45.653	56.754	0.00	100.00	0.00	0.00	0.00	2.7659	0.2517	0.2150	2.5112	2.7770	2.7375	0.2657	0.1569	0.1865
	-18		45.663	56.704	0.19	99.81	0.00	0.00	0.00	2.8202	0.4993	-4.0024	24.6955	2.8907	2.8859	0.2847	-0.1426	0.2278
	-24		45.658	56.451	0.00	99.84	0.16	0.00	0.16	2.9315	0.1987	0.3630	3.2030	2.9278	2.9153	0.1908	0.1076	0.1373
50	BASE OF BULK	146			0.00	100.00	0.00	0.00	0.00	1.7785	0.3269	0.3697	5.1716	1.7774	1.7848	0.3038	-0.0200	0.3262
	MIDBEACH	179			0.00	99.92	0.08	0.00	0.08	2.1902	0.4730	-0.0122	2.3392	2.1919	2.1765	0.4891	0.0207	0.3498
	TOE	262			0.00	100.00	0.00	0.00	0.00	1.7823	0.9047	-0.3201	1.9355	1.8026	1.9095	0.9072	-0.1693	0.4978
	-2	517			2.85	97.15	0.00	0.00	0.00	2.6338	0.6328	-2.3385	9.6422	2.7217	2.7879	0.5078	-0.4091	0.4404
	-6		45.192	56.698	0.00	100.00	0.00	0.00	0.00	2.0112	0.4978	-0.6613	3.5291	2.0263	2.0982	0.4879	-0.2552	0.4202
	-12		45.254	56.686	0.00	100.00	0.00	0.00	0.00	2.9752	0.2164	0.4165	3.2735	2.9716	2.9634	0.2157	0.0929	0.1563
	-18		45.261	56.561	0.00	100.00	0.00	0.00	0.00	2.9678	0.3978	-7.6880	73.5455	2.9998	3.0060	0.1808	-0.0622	0.1253
	-24		45.31	56.389	0.00	99.77	0.17	0.07	0.23	3.0102	0.1884	0.1340	2.9888	3.0077	3.0117	0.1936	-0.0044	0.1348